₹80/-

MAY 2025

AGRICULTURE TODAY

The National Agriculture Magazine

VOLUME XXVIII | ISSUE 5 www.agriculturetoday.in

From Crisis to Cure

THE CLIMATE COMEBACK

Padma Bhushan
Kamlesh D Patel

Bhupendra
Yadav

Giriraj Singh

Devendra Fadnavis

Eknath Shinde

Ajit Pawar

AGRICULTURE TODAY GROUP

presents

16th AGRICULTURE LEADERSHIP CONCLAVE 2025

9 - 10 JULY 2025 | New Delhi

16th Edition	500 + Attendees	20 + Awards Categories	50 + Speakers	2 Days

Who should Participate :

- Political Leaders, Policy Makers, and Diplomats
- Officials of Central and State Governments
- Industry Leaders and Agribusiness Executives
- Experts, Researchers, Academics, and Extension Personnel
- Banking, Insurance, Financial, Rural, and Development Professionals
- Farmers, Processors, Traders, Exporters, Media, and Extension Agencies
- Entrepreneurs, NGOs, KPOs (Knowledge Process Outsourcing), FPOs (Farmer Producer Organizations), Students, and Agribusiness Professionals

FOR MORE DETAILS, PLEASE CONTACT :

Ms. Zaman Almas | +91 - 7290088228 | zaman.almas@agriculturetoday.in

www.agriculturetoday.in/conclave

#ALC2025

Publisher & Printer – Dr. MJ Khan on behalf of M/s Concept Agrotech Consultants Limited, Published from 306 Rohit house Tolstoy Road New Delhi-110001 and printed by Everest Press E-49/8, Okhla Industrial Area-II New Delhi-110020
Phone No. 011-23731129 Fax No.011- 23731130
E-mail: editor@agriculturetoday.in
info@agriculturetoday.in

www.agriculturetoday.in
Page in the magazine: 60

FIGHTING CLIMATE CHANGE THROUGH SMARTER AGRICULTURE

Every year on April 22, we celebrate Earth Day—a timely reminder that our planet's health is inextricably linked to how we grow our food. Agriculture, both a contributor to and victim of climate change, holds the unique potential to lead the charge against it.

Climate change is no longer a distant threat; it's already impacting Indian agriculture with erratic rainfall, rising temperatures, depleting groundwater, and frequent extreme weather events. Farmers are at the frontlines of this crisis, and yet, they are also key to the solution.

To truly address this challenge, we must transform agriculture from being part of the problem to a central pillar of the solution. This means embracing climate-resilient farming practices—such as conservation agriculture, agroforestry, organic and regenerative farming, and better water and nutrient management. Promoting low-emission crops, integrating solar energy into irrigation, and supporting precision farming can help reduce the sector's carbon footprint.

But farmers can't do it alone. Policy intervention is critical. We need a shift from input subsidies to outcome-driven support—such as incentives for carbon sequestration, premium prices for low-emission crops, and climate-risk insurance schemes. Expanding carbon credit markets for farmers, investing in research and innovation, and integrating climate goals into schemes like PM-KUSUM and National Mission on Sustainable Agriculture can accelerate change.

Integrating crops like Bamboo can surely steer India's path towards a sustainable future. As one of the fastest-growing plants on Earth, it absorbs carbon dioxide at a significantly higher rate than many trees, making it a potent carbon sink. Its ability to grow on degraded land, prevent soil erosion, and regenerate rapidly without replanting makes it ideal for sustainable land management. Bamboo also offers eco-friendly alternatives to plastic, timber, and fossil fuels. Promoting bamboo cultivation not only supports climate resilience but also generates livelihoods, especially in rural and tribal communities. Maharashtra's bamboo revolution is a model of socio-economic transformation that can be emulated by the rest of the country.

On this Earth Day, let us reaffirm our commitment to a greener future—not just by planting trees, but by sowing policies and practices that help agriculture thrive in harmony with nature.

The earth can heal—but only if we grow wisely.

CONTENT

VOLUME XXVIII | ISSUE 05 | MAY 2025

The AGRI TODAY SHOW
by Haris Khan

THE NATIONAL PODCAST

Planting Knowledge, Harvesting Wisdom

Where policy meets passion and farming meets the future! This new venture brings together influential leaders, industry experts, entrepreneurs and policymakers to delve deep into the ever evolving world of agriculture.

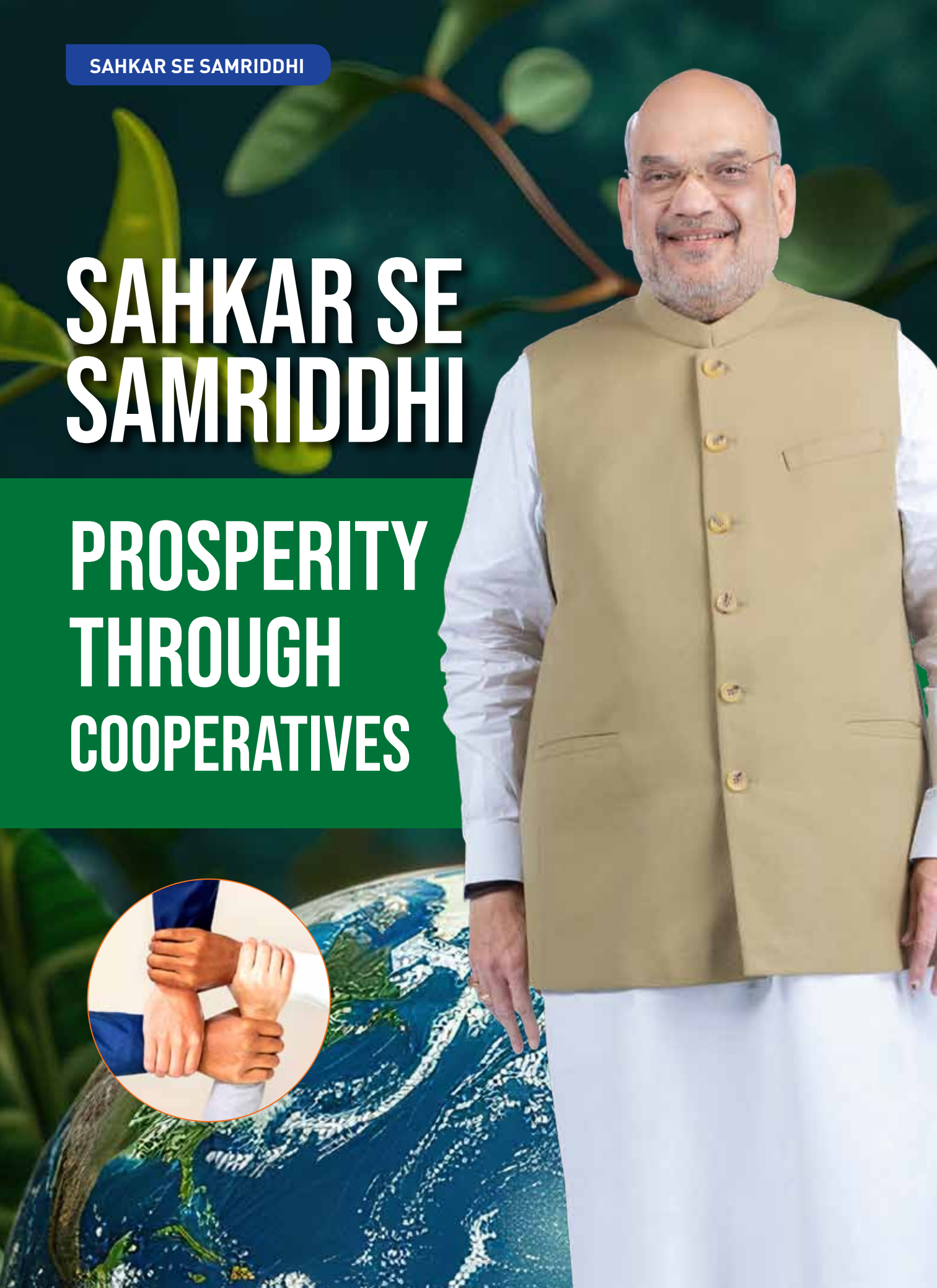
Our mission? *To engage the youth and bridge the gap between tradition and innovation, to make agriculture relevant and exciting for all. We discuss the "a to z" of agriculture; from policy debates to untold personal stories, from cutting edge agri-tech to its grassroot impact, each episode sows the seeds of knowledge for a greener and smarter tomorrow!*

"To Keep Yourself Abreast with the Latest in Agriculture"

| www.agriculturetoday.in

SAHKAR SE SAMRIDDHI

PROSPERITY THROUGH COOPERATIVES



"Prime Minister Narendra Modi, after establishing the ministry of cooperation, introduced the motto of 'Sahkar Se Samriddhi' (prosperity through cooperatives). Achieving this vision requires the presence of cooperatives in every panchayat, actively contributing in some capacity. Today there are 8 lakh cooperative societies in India and 30 crore people are their members. In a way, every fifth person in the country is associated with cooperatives, but no effort was made for its development in the past 75 years. "

"The only way to connect a person without capital with entrepreneurship is Cooperation. Through Cooperation crores of people with small capital are coming together to start their businesses and are living with dignity by generating self-employment. In a country like India with a population of over 130 crore, employment is a big indicator of the health of the country's economy, along with GDP. Cooperatives are the only sector that connects 130 crore people with the country's development through self-employment and also protects their dignity. "

For the first time since independence, a separate Ministry of Cooperation was created in 2021 to give focused attention to the cooperative sector. The ministry aims to streamline processes, strengthen cooperatives, and deepen their reach.

"Prime Minister Narendra Modi, after establishing the ministry of cooperation, introduced the motto of 'Sahkar Se Samriddhi' (prosperity through cooperatives). Achieving this vision requires the presence of cooperatives in every panchayat, actively contributing in some capacity. Today there are 8 lakh cooperative societies in India and 30 crore people are their members. In a way, every fifth person in the country is associated with cooperatives, but no effort was made for its development in the past 75 years."

Vision for Cooperatives:

- **"Sahkar se Samriddhi"**: Prosperity through cooperation
- Shift cooperatives from **traditional to modern enterprises**
- Promote **digitization, professionalism, and scale**
- Empower cooperatives to **serve as engines of rural economic transformation**

PACS Digitization Program

A Rs. 2,516 crore project was launched to computerize all 63,000+ Primary Agricultural Credit Societies (PACS) across India to enhance transparency, efficiency, and integration with core banking systems. Unified software is being developed for real-time data access and improved service delivery.

"This modernization has enabled the integration of PACS with 32 diverse activities, including storage, manure, gas, fertilizer, and water distribution, making them more versatile and effective. 2 lakh new Primary Agricultural Cooperative Societies (PACS) will be formed in the country and there will not be a single Panchayat in the country where there will not be a PACS. 43 thousand PACS Common Service Centres (CSCs) have been established in the country where benefits and facilities of more than 300 schemes of the Central and State Government are available. Today 36 thousand PACS are working as PM Samridhi Kendras in the country, 4 thousand PACS have been established as Jan Aushadhi Kendras and 400 PACS are also running petrol pumps. The Modi government started the world's largest grain storage scheme and so far 576 PACS have started the work of building godowns. Today, out of these 67,930 PACS, 43,658 PACS are working through computers. Now their accounts are reconciled in the evening, along with online audit, all business is also done online. Computerization has brought a revolution in the cooperative sector.

Model Bylaws for PACS (2022-23)

Model Bylaws were released to standardize functioning across states. It allows PACS to undertake 20+ new economic activities, including setting up common service centres (CSCs), LPG distribution, dairy, and fertilizer outlets. It also aims to transform PACS into multi-functional rural economic hubs.

"Seva Sahkari Mandali (PACS) will be made multipurpose with facilities for marketing, godowns, making gobar (dung) gas, electricity bill collection, facility for gas distribution agencies, Nal Se Jal scheme, etc. The country's PACS will be multi-purpose and profit making.''

Establishment of Three National-Level Multistate Cooperative Societies (2023)

To expand the role of cooperatives nationally, three major apex cooperatives were announced

1. **National Cooperative Export Society (NCES)** – To facilitate cooperative participation in global trade.
2. **National Cooperative Organic Society (NCOS)** – To promote organic farming and certification.
3. **National Cooperative Seed Society (NCSS)** – To produce and distribute quality seeds to farmers via cooperatives.

"Cooperative is the only sector which touches lives of crores of people and has potential to bring positive changes for them. It had, however, remained neglected for years. The Modi government has taken initiatives to strengthen it. The Cabinet has taken three decisions for the interest of the cooperatives.... This decision will strengthen the cooperative sector.»

Launch of National Cooperative Database (Ongoing)

It aims to create a unified digital database of all cooperative societies across India and is expected to help in better policy planning, fund allocation, and monitoring.

"The cooperative database will play a crucial role in the expansion of cooperatives, digital development, and delivery through databases. Data works to guide development in the right direction and will be highly effective in analyzing gaps. We are experiencing a new trend in this era – data governance, proactive governance, and anticipatory governance. The synergy of these three leads to the establishment of a new development model."

Formation of Cooperative University (Planned)

The **establishment of a National Cooperative University** was announced to train professionals, office bearers, and youth in cooperative governance and management.

"In view of the development and expansion of the cooperative sector, trained human resources are needed and Tribhuvan Sahkari University will work to fulfill this need. After the formation of a cooperative university, its diploma and degree holders will get jobs. Through this university, we will make a big contribution to the domestic as well as global value chain. New age cooperative culture will also start from this university."

Tax Relief and Budgetary Support (Union Budgets 2022–24)

The finance ministry has lowered tax rates for cooperative societies to 15% (same as corporates), increased cash withdrawal limit for cooperatives without TDS to Rs.3 crore and has given higher credit limits to PACS and multi-state cooperatives.

Promoting Cooperative Exports and Branding

B**randing and global promotion of cooperative products has been encouraged**, especially dairy, handloom, and organic produce. Cooperative societies have been enabled to directly register as exporters.

"About 8 thousand PACs have been associated with the National Cooperative Export Limited (NCEL) and through these, our farmers' products are being exported abroad. So far, 12 lakh tonnes of materials have been sold in the global markets through NCEL and the profit is being deposited directly into the farmers' accounts."

Support to Women and Tribal Cooperatives

Women-led cooperatives and tribal forest produce cooperatives (especially in bamboo, tendu leaves, and lac) are being actively promoted. Also emphasis has been laid on inclusive and equitable development through targeted schemes.

Legal and Structural Reforms in Multi-State Cooperatives

Multi-State Cooperative Societies Act (2022) was introduced which has provision for cooperative ombudsman to handle member grievances. Audit and transparency norms were introduced. Framework for board elections, merger, and winding up were also introduced.

"Following the formation of the Cooperation Ministry, all changes have been made to the Multi-State Cooperative Societies Act as per the 98th Amendment. Several issues were there for running a cooperative society. However, the Multi-State Cooperative Societies (Amendment) Act, 2023, has resolved all such issues."

COOPERATIVES AGAINST CLIMATE CHANGE

Empowering Cooperatives to Lead The Bamboo Revolution

Climate change is one of the defining challenges of our time, which is driving a steady and alarming rise in global temperatures. Over the past century, Earth's average temperature has risen by about 1.1°C, with the last decade being the warmest on record. Melting glaciers, rising sea levels, and extreme weather events such as heatwaves, wildfires, and hurricanes are all linked to this temperature increase. Polar regions are warming at more than twice the global average, disrupting ecosystems and global climate patterns.

This rise in temperature has a multifaceted effect on food and water security, human health, biodiversity, and economies worldwide. Without urgent action to reduce emissions and adopt sustainable practices, global temperatures could exceed the 1.5°C threshold set by the Paris Agreement, leading to irreversible damage. Sectors across continents are adopting strategies to reduce their carbon foot print and greenhouse gas emissions. However at grass root level mitigation and adaptation strategies need to gain stronger foothold.

With increasing carbon emissions, frequent natural disasters, and ecosystem degradation, it has become imperative to adopt sustainable, inclusive, and community-led solutions. In this context, cooperatives emerge as powerful vehicles of change, particularly in rural India. With over 2 lakh cooperative societies spread across virtually every village, these institutions are rooted in community participation, mutual benefit, and collective decision-making.

As India searches for green solutions to mitigate climate change and boost rural livelihoods, bamboo emerges as a key resource—renewable, fast-growing, and highly efficient in carbon sequestra-

tion. Empowering cooperatives to lead bamboo cultivation and promotion efforts not only address climate goals, but also creates economic opportunities at the grassroots level.

Cooperatives: India's Largest Rural Network

India's cooperative movement has a rich legacy, spanning across agriculture, credit, dairy, and housing sectors. From the Amul dairy cooperative in Gujarat to self-help groups in the Northeast, cooperatives have consistently demonstrated their ability to mobilize communities, democratize development, and empower marginalized groups.

What makes cooperatives ideal for climate action is their deep penetration in rural India, community ownership, and focus on long-term sustainability. Whether it's managing common property resources, facilitating sustainable agriculture, or promoting renewable energy, cooperatives are uniquely positioned to integrate environmental and economic priorities.

Climate Change and the Bamboo Opportunity

Bamboo, often referred to as "green gold," is increasingly recognized as a strategic natural resource in climate mitigation. It is one of the fastest-growing plants on Earth, with some species growing up to 1 meter per day. Bamboo:

- **Sequesters carbon** at higher rates than many trees
- **Restores degraded land** and prevents soil erosion
- **Requires minimal water and inputs** compared to conventional crops
- **Provides livelihood** through multiple value chains—from handicrafts to construction materials

India is home to nearly 30% of the global bamboo species, making it a biodiversity hotspot. However, bamboo remains vastly underutilized due to policy constraints, lack of awareness, and market linkages. This is where cooperatives can step in as transformative agents.

Cooperatives are Best Suited for Bamboo Promotion

- **Community Ownership**: Bamboo plantations are best developed on degraded lands, community lands, and along field bunds—all of which are often under the informal control of village communities. Cooperatives ensure community ownership, equitable benefit-sharing, and long-term stewardship.
- **Local Capacity Building**: Through training, workshops, and shared learning, cooperatives can build the capacity of rural populations in bamboo cultivation, nursery development, pest management, and harvesting.
- **Access to Credit and Inputs**: Cooperatives, particularly primary agricultural credit societies (PACS), can provide affordable credit, inputs like seedlings, and equipment for bamboo farming and processing.
- **Market Linkages and Value Addition**: Many cooperatives already operate agro-processing units. With proper planning, bamboo-based products like furniture, agarbatti sticks, charcoal, biochar, and flooring materials can be promoted through cooperative enterprises.
- **Policy Interface**: Cooperatives can serve as an intermediary between farmers and government schemes such as **the National Bamboo Mission (NBM)** and various state-level climate action plans, facilitating convergence of funds and technical support.

Bamboo, often referred to as "green gold," is increasingly recognized as a strategic natural resource in climate mitigation

Cooperatives Driving Bamboo-Based Development in India

Tripura Bamboo Mission and Cooperatives

Tripura, a northeastern state with significant bamboo resources, launched the Tripura Bamboo Mission (TBM) to promote bamboo-based industries and livelihoods. Cooperatives and self-help groups (SHGs) were central to this effort. The initiative provided training, developed bamboo clusters, and facilitated marketing. As a result over 15,000 artisans were trained and employed. The cooperatives there helped set up bamboo-processing units and as a result the state witnessed a sharp increase in bamboo-based handicrafts and agarbatti production. TBM's suc-

cess lies in its decentralized approach, where cooperatives played a pivotal role in implementation and community mobilization.

Maharashtra's Bamboo Cooperatives

In Gadchiroli and Chandrapur districts of Maharashtra, tribal communities have long depended on bamboo for livelihood. Recognizing this, several forest cooperatives were created under the Minor Forest Produce (MFP) scheme. These cooperatives have been involved in sustainable bamboo harvesting from forest areas. They are also engaged in primary processing and direct marketing, thereby eliminating middlemen. members were able to generate a significant income for members while maintaining ecological balance.This model showcases how cooperatives can balance environmental conservation with rural incomes.

NABARD's Support to Bamboo Cooperatives

The National Bank for Agriculture and Rural Development (NABARD) has supported numerous cooperative initiatives focused on bamboo. One notable example is in Bastar, Chhattisgarh, where bamboo cooperatives received support for: Setting up nurseries and plantations on degraded lands; Training tribal communities in value addition snd Linking artisans to urban markets. These cooperatives became self-sustaining enterprises, offering both climate resilience and livelihood security.

Bamboo Cooperatives: A Multi-Win Solution

The potential of bamboo-based cooperatives goes beyond climate change mitigation. It offers multiple co-benefits, including:

- **Livelihood Generation**: Bamboo processing units, crafts, and small-scale industries can create large-scale rural employment, especially for women and youth.
- **Land Restoration**: Bamboo helps rejuvenate degraded land, which is widespread across many parts of India.
- **Bioenergy**: Bamboo biomass can be used for biofuels and energy generation.
- **Sustainable Construction**: Bamboo structures have a lower carbon footprint compared to steel or cement, making it ideal for eco-housing and public infrastructure.

Cooperatives ensure community ownership, equitable benefit-sharing, and long-term stewardship.

Moreover, climate-smart cooperatives using bamboo can also access global carbon finance mechanisms like carbon credits.

Way Forward: Scaling up Bamboo through Cooperatives

For India to fully leverage its cooperative network and bamboo wealth, certain strategic actions are needed:

- **Policy Support and Deregulation**

Despite the 2017 amendment removing bamboo from the "tree" category in the Indian Forest Act, many state-level restrictions still hamper bamboo transport and trade. Governments must ease these norms and provide incentives for bamboo cooperatives.

- **Integration with National Missions**

Bamboo promotion must be integrated into the National Rural Livelihood Mission (NRLM), MGNREGA, and the National Action Plan on Climate Change (NAPCC). Cooperatives can act as executing agencies for bamboo-related climate adaptation and mitigation projects.

- **Capacity Building and Technical Training**

Dedicated training centres and mobile units should be set up to train cooperative members in bamboo propagation, pest control, harvesting techniques, and design innovation.

- **Financing and Risk Sharing**

Soft loans, startup grants, and crop insurance schemes for bamboo should be channelized through cooperative credit institutions. NABARD and district cooperative banks can play a lead role here.

- **Branding and Marketing**

Cooperatives must be supported to build brands around bamboo products—focusing on eco-friendliness, sustainability, and indigenous heritage. Digital platforms, e-commerce tie-ups, and government expos can give them visibility.

As India charts its path towards climate resilience and inclusive development, cooperatives can become the backbone of a green rural economy. By promoting bamboo cultivation and utilization, they can combat climate change, restore ecosystems, and generate sustainable livelihoods for millions. The convergence of community power (cooperatives) and nature-based solutions (bamboo) represents a model for climate action that is local, inclusive, and scalable. With appropriate support, this synergy can not only transform India's villages but also offer a replicable model for the world. Empowering cooperatives to lead the bamboo revolution is not just an environmental imperative—it is a national mission for rural prosperity.

INDIA – A GLOBAL HUB FOR GREEN ENERGY AND GREEN MOBILITY

BIOFUELS AND CLIMATE-FRIENDLY TRANSPORT

"Our aim is to make India a global hub for biofuels. Ethanol, methanol, biodiesel, and green hydrogen are not just fuels—they're a mission for clean energy."

"By blending ethanol with petrol, we are not just reducing pollution, but also saving foreign exchange and increasing farmers' income."

"Biofuel is the future of transport. We must move from fossil fuels to green fuels to tackle both climate change and economic dependency."

"We are working to introduce flex-fuel engines in India, where vehicles can run 100% on ethanol. This is a game-changer for environment and energy security."

"India is promoting second-generation ethanol from bamboo and biomass—this will not only reduce GHG emissions but also generate rural employment."

BAMBOO AS A CLIMATE AND ECONOMIC RESOURCE

"Bamboo is green gold. It is a fast-growing, carbon-sequestering plant that can revolutionize India's rural and tribal economy."

"We have planned to promote bamboo as a raw material for bio-CNG, ethanol, and even construction—it's a versatile,

eco-friendly alternative."

"I have urged the Ministry of MSME and rural development to integrate bamboo into village industries. It can generate thousands of jobs and reduce plastic usage."

"Bamboo is not just about crafts—it is India's answer to sustainable construction, renewable energy, and climate mitigation."

ON GLOBAL WARMING AND CLIMATE CHANGE

"Climate change is no longer a future threat—it is our present crisis. The transport and energy sectors must decarbonize urgently."

"India must lead the world in climate-friendly infrastructure—by shifting to electric vehicles, biofuels, and green logistics."

"We are building highways with alternative materials and technologies to reduce the carbon footprint of construction activities."

"Decentralized, green energy like solar, ethanol, and hydrogen is the answer to our dual challenge of pollution and climate change."

SUSTAINABILITY AND INNOVATION IN POLICY

"We cannot replicate the pollution-intensive industrialization model of the West. India's growth must be green, inclusive, and innovation-driven."

"My ministry is promoting green highways, electric mobility, biofuel blending, and alternative construction methods as part of our climate strategy."

GREEN TRACTORS

"We have launched India's first electric tractor, and it's a revolutionary step towards green farming. It will reduce the cost of cultivation and promote clean energy in agriculture. Electric tractors will not only reduce the burden of diesel costs on farmers but also help the environment by reducing emissions."

"I have asked tractor manufacturers like Mahindra and Escorts to develop tractors that run on 100% ethanol. It is a cleaner, cheaper alternative and supports our farmers who produce sugarcane and maize. If we can make cars and buses run on ethanol, then why not tractors? It will increase the income of our farmers and reduce import bills."

"I launched India's first CNG tractor, which will help farmers save ₹1 lakh per year on fuel. This is a green alternative that uses agricultural waste to produce fuel. Bio-CNG made from crop residue can be used to power tractors. This will address the problem of stubble burning and promote rural bioeconomy."

"Hydrogen is the fuel of the future. We are exploring hydrogen fuel cell technology for agricultural vehicles. It is zero-emission and very promising. We will soon have tractors running on green hydrogen made from water using solar energy."

"By using ethanol, electric, and CNG in agriculture, we are promoting Atmanirbhar Bharat. This is our path to self-reliance and sustainable farming. Our goal is to reduce dependence on fossil fuels and empower farmers through alternative energy sources in the agriculture sector."

BAMBOO: THE GREEN GOLD
POWERING INDIA'S RURAL REVIVAL AND CLIMATE RESILIENCE

As India advances toward a greener and more inclusive future, few natural resources offer as much transformative potential as **bamboo**. Revered as *"green gold,"* bamboo is far more than a fast-growing plant—it symbolizes ecological restoration, rural empowerment, and climate resilience. With its rapid regeneration, unparalleled versatility, and environmental benefits, bamboo stands poised to become a cornerstone of India's sustainable development strategy.

Bamboo: An Ecological Powerhouse

Bamboo is one of nature's most powerful allies in combating environmental degradation. Among the fastest-growing plants on Earth, it matures in just 3 to 5 years and can sequester up to 40 tons of carbon dioxide per hectare per year, outperforming many traditional tree species in carbon capture.

Its extensive root system prevents soil erosion, stabilizes riverbanks, raises water tables, and rejuvenates degraded landscapes. A single bamboo clump can anchor up to 6 cubic meters of soil, making it invaluable in halting desertification. Moreover, bamboo's evergreen canopy sheds nutrient-rich leaves throughout the year, generating 6 to 8 inches of humus annually—vital for agroforestry, climate-resilient farming, and soil restoration.

Among the fastest-growing plants on Earth, it matures in just 3 to 5 years and can sequester up to 40 tons of carbon dioxide per hectare per year, outperforming many traditional tree species in carbon capture.

About the **AUTHOR**

Shri Suresh Prabhu, Former Union Cabinet Minister, Government of India & Chancellor, Rishihood University

An Economic Catalyst for Rural India

Beyond its ecological advantages, bamboo presents a significant economic opportunity—especially for rural communities and smallholders. Unlike seasonal crops, bamboo offers year-round income with minimal input costs. It thrives on degraded land, along field boundaries, and near homesteads—making it ideal for decentralized cultivation.

With the global bamboo market valued at over $100 billion, Indian farmers have a unique chance to participate in this growing green economy. A leading example is the Konkan Bamboo and Cane Development Centre (KONBAC) in Maharashtra's Sindhudurg district. Established in 2004, KONBAC has revolutionized bamboo's image from "the poor man's timber" into a symbol of sustainability and innovation. Through skill development, design-led value addition, and market access, KONBAC has empow-

ered thousands—particularly women and youth—to create premium bamboo products ranging from furniture to prefabricated structures.

Bamboo in Industry: A Sustainable Substitute

With a tensile strength comparable to steel, bamboo is emerging as a low-carbon alternative to conventional construction materials. Its durability, renewability, and aesthetics have captured the interest of architects, designers, and green builders alike.

During my tenure as Union Minister of Environment and Forests, India's formal accession to International Bamboo and Rattan Organisation (INBAR), marked a milestone in our national commitment to bamboo as both an ecological and industrial asset.

Policy Innovation: Unlocking Bamboo's Full Potential

The National Bamboo Mission (NBM), launched in 2006-07, has played a role in nurturing the bamboo value chain—from plantation to processing and market linkages. Yet, realizing bamboo's full potential requires continued policy innovation and bold reforms.

One promising approach is the hub-and-spoke model, where cultivation and primary processing are decentralized at the village level, while regional hubs house advanced processing units. Aligning bamboo development with the Sustainable Development Goals (SDGs) and principles of the circular economy will magnify its environmental and socio-economic impact.

A pivotal reform came in 2017, when the Government of India—under the visionary leadership of Hon'ble Prime Minister Shri Narendra Modi—amended the Indian Forest Act, 1927, to exclude bamboo grown on non-forest land from the definition of a "tree." This landmark decision eliminated licensing hurdles for harvesting and transporting bamboo, empowering farmers and entrepreneurs to cultivate it freely. As a result, bamboo is now flourishing on private land, while allowing natural forests to regenerate undisturbed.

With a tensile strength comparable to steel, bamboo is emerging as a low-carbon alternative to conventional construction materials.

Maharashtra Leads the Bamboo Revolution

A path-breaking development came when the Government of Maharashtra allocated an unprecedented ☐4,300 crore in its annual budget to revitalize the bamboo sector. Under the leadership of Hon'ble Chief Minister Shri Devendra Fadnavis, this initiative seeks to embed bamboo into the very fabric of the state's economic development strategy.

The plan includes the establishment of processing clusters and bamboo-based skill centres, aimed at generating employment across tribal communities, rural youth, and skilled professionals—turning bamboo into a driver of both prosperity and sustainability.

Policy-Driven Demand: Bamboo for Energy and Industry

Recognizing bamboo's role as a renewable energy source, the Government of India has mandated all coal-based thermal power plants to blend at least 5% biomass pellets with coal—with bamboo officially approved as a feedstock. This move creates a sustained and large-scale demand for bamboo, offering farmers a dependable market and incentivizing long-term cultivation.

In the steel sector, a groundbreaking milestone was achieved when Durgapur Steel Plant (a unit of SAIL) successfully conducted India's first industrial-scale trial using 300 tonnes of bamboo biochar in its sintering process. By replacing 20% of the traditional coke breeze with bamboo biochar, the trial achieved a 15–20% reduction in CO☐ emissions. This innovation, supported by the Ministry of Steel's Task Force on Biochar, demonstrates bamboo's immense potential as an industrial decarbonization tool—and signals a future of low-emission steel production powered by sustainable agriculture.

Bioethanol and Beyond: Bamboo in India's Green Energy Transition

India's clean energy ambitions received a major boost with the launch of a ☐4,200 crore second-generation (2G) bio-refinery in Numaligarh, Assam. This facility will annually produce:

- 50,000 MT of bioethanol
- 18,000 MT of furfural
- 11,000 MT of acetic acid

All derived from bamboo, this initiative positions the plant as a key node in India's emerging bioeconomy. For farmers, it means long-term demand and income security—even amidst erratic weather patterns and climate volatility.

A Circular Future Rooted in Bamboo

Bamboo is more than a plant—it is a metaphor for regeneration, resilience, and inclusive growth. It captures the essence of the circular economy: reducing waste, reusing resources, and restoring ecosystems. By mainstreaming bamboo into our agriculture, industries, policies, and design thinking, we can build a future that is both prosperous and sustainable.

As India faces the twin challenges of climate change and rural distress, bamboo offers a homegrown solution with global relevance. With its unique blend of ecological and economic value, India is poised to lead a global bamboo renaissance—and the time to act is now.

Let us make bamboo the heart of India's sustainable development story.

THE BAMBOO REVOLUTION IN MAHARASHTRA

As the world grapples with the grave challenges of climate change—rising temperatures, depleting natural resources, and an alarming increase in natural disasters—it is becoming ever more evident that our survival depends on restoring harmony with nature. With atmospheric carbon dioxide levels now at a staggering 422 parts per million—far exceeding the safe threshold of 350 ppm—we must urgently rethink our development paradigm. In this context, bamboo emerges not just as a plant, but as a symbol of ecological resilience, economic empowerment, and sustainable innovation.

Bamboo: The Green Gold

Bamboo is one of the fastest-growing plants on Earth—some species can grow up to a meter a day. Yet, its true value lies in its remarkable environmental benefits. A single hectare of bamboo can sequester up to 40 tonnes of CO□ annually. Its dense root system prevents soil erosion, conserves moisture, and rejuvenates degraded land—making it ideal for watershed development and land restoration.

About the **AUTHOR**

Shri Pasha Patel, Chairman, Agricultural Price Commission, Government of Maharashtra (Cabinet Minister Rank) Executive Chairman, Chief Ministers Task Force for Environment and Sustainable Development, GoM

The Numaligarh Refinery in Assam, home to the world's first bamboo-based ethanol plant, will soon produce 6 crore liters of ethanol annually from 3 lakh tonnes of bamboo.

But bamboo is much more than a tool for environmental healing. It is an incredibly versatile resource, capable of replacing timber, plastic, steel, and even fossil fuels. With over 1,800 documented uses—including construction materials, biodegradable products, textiles, furniture, incense sticks, ethanol, biochar, and even aviation fuel—bamboo is truly a *Kalpavriksha*, a wish-fulfilling tree for farmers, industries, and the environment alike.

Justice for Bamboo: A Policy Breakthrough

For decades, bamboo's potential was stifled by colonial-era regulations. Under the Indian Forest Act of 1927, bamboo was classified as a tree, placing it under strict forest department control. Farmers required cumbersome permissions to harvest and transport bamboo—making cultivation unviable.

This changed dramatically in 2017 when Prime Minister Narendra Modi's government amended the Act, reclassifying bamboo as a grass. This visionary policy reform liberated bamboo from bureaucratic shackles, allowing farmers to grow, harvest, and sell it freely. Thus began the *Bamboo Revolution*—an era where bamboo became a viable commercial crop and a symbol of rural prosperity.

Rooting the Revolution in Maharashtra

Maharashtra, under the progressive leadership of then Chief Minister Shri Eknath Shinde, has become a national pioneer in bamboo cultivation. The state's *Green Maharashtra* initiative actively promotes bamboo plantations under the MGNREGA scheme, offering

subsidies of up to ₹7 lakh per hectare.

The Chief Minister has also constituted a Task Force on Environment and Sustainable Development to promote bamboo as a climate-resilient crop across the state. These measures not only make bamboo cultivation financially rewarding but also provide farmers with employment and income stability in the early years before bamboo reaches maturity.

Bamboo and Bioenergy: Fuelling a Greener Future

India's energy transition cannot rely solely on solar and wind power—bioenergy will play a vital role. Bamboo is poised to be the backbone of this shift. The Numaligarh Refinery in Assam, home to the world's first bamboo-based ethanol plant, will soon produce 6 crore liters of ethanol annually from 3 lakh tonnes of bamboo.

Let us compare:

- **1 ton of sugarcane** yields **80 liters of ethanol**, consuming **over 1 lakh liters of water**.
- **1 ton of bamboo** yields **200 liters of ethanol**, using just **20,000 liters of water**.

Clearly, bamboo is far more water-efficient and energy-dense. Its high calorific value also makes it ideal for biomass-based thermal power plants, now mandated to use a minimum of 5% biomass. Under India's biomass policy, this creates a reliable, growing market for bamboo pellets.

In addition, pilot experiments by Steel Authority of India at the Durgapur Steel Plant using bamboo-derived biochar show promising results in reducing industrial emissions. Maharashtra is also exploring bamboo fiber production in collaboration with companies like the Aditya Birla Group—reducing import dependency, creating rural jobs, and supporting sustainable textiles.

Bamboo: Nature's Climate Warrior

Every bamboo culm is a climate soldier. A single plant generates up to 320 kilograms of oxygen annually. When planted on fallow, saline, or degraded lands, bamboo revives the soil and restores ecological balance.

Bamboo aligns perfectly with India's international climate commitments and Sustainable Development Goals (SDGs). It does not compete with food crops, and farmers can inter-crop for the first two years. From the fourth year onward, bamboo can be sustainably harvested annually for over 40 years—offering stable, long-term income.

A Transformation Beyond Agriculture

Maharashtra's bamboo revolution is more than a crop promotion—it is a model of socio-economic transformation rooted in sustainability. Bamboo plantations:

- Provide secure, long-term income to farmers.
- Reduce rural distress and migration.
- Contribute to India's clean energy, green housing, and sustainable manufacturing goals.

Since 2017, the **Phoenix Foundation**, which I am privileged to lead, has spearheaded this movement. Through over 3,000 awareness drives, workshops, and technical trainings, we've partnered with farmers, artisans, and local governments to build a grassroots bamboo-based economy. Our mission is to establish a comprehensive bamboo ecosystem—from plantation to finished products—generating employment, conserving the environment, and nurturing local industries.

The Road Ahead: A Call to Action

The Bamboo Revolution in Maharashtra has only just begun. To realize its full potential, we must strengthen collaboration among all stakeholders—government, industry, academia, research institutions, and most importantly, farmers.

We must:

- Establish bamboo clusters tailored to local agro-climatic zones.
- Attract private investment in bamboo processing and value chains.
- Promote bamboo-based construction, packaging, and furniture industries.
- Integrate bamboo into school and university curricula.
- Incentivize carbon trading and green certification for bamboo products.

Bamboo offers us a rare chance to align economic development with ecological stewardship. Let us seize this opportunity.

Jai Jawan, Jai Kisan, Jai Bamboo!

To the farmers of Maharashtra and across India—plant bamboo not just as a crop, but as a commitment to the Earth. Grow it even along riverbanks, on degraded lands, roadsides, and watersheds. Secure your family's future, protect the environment, and become a part of a transformative movement for a greener, more prosperous India.

Bamboo

GREEN GOLD FOR A GREENER PLANET

The Sindhudurg Success Story: A Silent Revolution

In the lush green landscapes of Sindhudurg, a coastal district nestled in the Western Ghats of Maharashtra, a quiet but powerful revolution has been reshaping the local economy and redefining sustainable development. This transformation began in 1998, when India joined the International Network for Bamboo and Rattan (INBAR) under the visionary leadership of the then Union Environment Minister, Hon. Suresh Prabhu. This move laid the foundation for a bamboo-based green economy in India—a step that would bear fruit in the years to come.

By 2004, the seeds of a larger movement were sown with the establishment of the Konkan Bamboo and Cane Development Centre (KONBAC) in Kudal. Founded by engineer-turned-social entrepreneur Sanjeev Karpe, KONBAC was supported by INBAR and the Centre for Indian Bamboo Resource and Technology (CIBART). The not-for-profit company envisioned bamboo not as a relic of tradition but as a modern, resilient, and valuable resource capable of transforming lives and landscapes alike.

Sindhudurg, with its hilly terrain, rain-fed farms, and rich biodiversity, was once dependent on fruit crops like mango and cashew. However, these crops were often vulnerable to erratic climate conditions and market fluctuations. Bamboo, particularly the native species *Dendrocalamus stocksii*—locally known as *Managa bamboo*—emerged as an ideal alternative. It was hardy, fast-growing, and capable of thriving in varied conditions, while also offering significant income opportunities.

KONBAC recognized early on that to truly make bamboo a viable alternative to conventional materials, it had to be elevated beyond its image as the "poor man's timber."

Cultivating a Green Economy

KONBAC's first step was to empower the farming community through education. It launched extensive outreach programs focused on hands-on training in bamboo propagation, cultivation, and harvesting. What began with 120 farmers in 2004 has today grown into a movement of more than 10,000 farmers cultivating bamboo across 5,500 hectares in Sindhudurg.

"We showed farmers how bamboo could survive harsh weather and provide long-term economic benefits," says Karpe. "Slowly but surely, they began to see bamboo not just as a crop, but as a reliable income source."

One of these farmers, Sunil Sawant, who now grows bamboo on his 25-acre farm in Hirlok, Kudal, shares, "Earlier, we only grew rice and weren't aware of bamboo's potential. KONBAC helped us realize its immense market demand. Now, we use no fertilizers and follow organic methods, and our income has significantly increased."

Farmers like Sunil now sell bamboo to KONBAC at nearly double the market rate—₹120 per piece compared to ₹70 elsewhere. This has not only improved rural incomes but also built a dependable supply chain rooted in sustainability.

About the **AUTHOR**

Sanjeev Karpe is the Director, KONBAC, Kudal, Sindhudurg, Maharashtra

From Craft to Construction: The Artisan Economy

Bamboo's story in Sindhudurg does not end with farming. The next chapter unfolds through skill development and value addition. KONBAC started training artisans in crafting premium bamboo products—ranging from furniture and home decor to customized structures.

Among them is Eknath Gavandi, a former carpenter who now crafts bamboo furniture. "Working with bamboo is both a challenge and a joy. Unlike wood, every piece of bamboo is unique. There's more manual craftsmanship involved, which keeps the work exciting," he says.

KONBAC recognized early on that to truly make bamboo a viable alternative to conventional materials, it had to be elevated beyond its image as the "poor man's timber." Thus, it invested in pressure-vacuum treatment plants to ensure bamboo products are durable and weather-resistant. These treated bamboo items now grace eco-resorts, five-star hotels in Goa, showcasing their high-end appeal.

To foster inclusivity, KONBAC also engaged rural women in its production processes. From making bamboo nails and splits to assembling furniture components, women contribute through home-based part-time work, earning steady income and gaining recognition as skilled artisans.

Taking Indian Bamboo to the World

Sanjeev Karpe's vision was never confined to the lush hills of Sindhudurg. Together with Krunal Negandhi, then Environmental Head of the Lavasa project, both of them founded JANS Bamboo Products Pvt. Ltd., a company dedicated to crafting innovative and customized bamboo structures. This collaboration marked the beginning of an exciting chapter in India's bamboo journey.

Their first international breakthrough came through a global tender for a luxury dining experience in the Maldives. The project was for the prestigious Waldorf Astoria resort, which originally requested a metal structure clad in bamboo for aesthetic appeal. However, Karpe and his team proposed a far bolder idea—a fully bamboo-based design, engineered to withstand the tropical marine climate.

"The client wanted a metal structure with bamboo cladding," recalls Karpe. "But we suggested going all-in with bamboo. To their credit, they embraced the idea. The result was a spectacular waterfront restaurant that not only withstood severe sea storms but also earned a place on CNN UK's list of the Top 16 Waterfront Restaurants in the World."

The Maldives success story opened international doors. Soon after, JANS Bamboo secured a contract to supply bamboo ceiling panels for the FIFA World Cup 2022 in Qatar, specifically for facilities housing international players. Manufactured at JANS' facility in Kudal, Maharashtra, and assembled on-site in Qatar, the ₹5-crore project showcased the power of Indian bamboo craftsmanship on a global stage.

Changing Mindsets, Building Futures

Despite the accolades and international recognition, Karpe remains grounded in a broader mission—to transform the way bamboo is perceived in India.

"Bamboo is still seen as the poor man's timber," he says. "But in reality, it is perhaps the most sustainable material on Earth. It grows rapidly, absorbs more carbon dioxide than trees, and is the only material that emits oxygen even during its processing."

KONBAC and JANS are working to reshape this perception by demonstrating bamboo's versatility and elegance—from small rural farms to elite hospitality destinations. Their work is helping elevate bamboo's image as a material fit for premium applications, while also supporting rural livelihoods.

In addition, KONBAC has incubated a social enterprise called Native KONBAC Bamboo Products Pvt. Ltd., dedicated to producing high-quality furniture and décor. These products are now reaching global customers through WoodyGrass.com, an e-commerce platform created to compete with international markets and showcase the finest in Indian bamboo craftsmanship.

Earth Day and the Promise of Bamboo

As we celebrate World Earth Day, bamboo stands tall as a symbol of climate resilience, rural prosperity, and industrial innovation. It is not just a plant—it is a movement, rooted in sustainability and growing towards global impact.

From the rain-fed farms of Sindhudurg to architectural marvels across oceans, bamboo has proven its worth. With visionary leadership, strong policy support, and empowered communities, India—especially Maharashtra—is poised to lead the global bamboo economy.

The green revolution we seek is already taking root. It's time we nurture it, scale it, and let it grow—because the future we need is one we build today.

CHASING THE TASK OF SUSTAINABLE AGRICULTURE AMID BURGEONING CLIMATE WOES

Climate change stands as one of the most urgent challenges of our era. It is threatening ecosystems, economies, and communities across the globe. According to the World Meteorological Organization (WMO), 2024 was the hottest year on record, with global temperatures surpassing 1.5°C above pre-industrial levels. As the climate crisis intensifies, all stakeholders must implement strong adaptation and mitigation strategies to enhance agricultural resilience and ensure long-term sustainability.

Climate Change and Pressure on Farmers

Farmers around the world are dealing with enormous challenges. They are on the front line of climate change, which is posing a serious threat to our food security. The climate change impact assessment, carried out by the Government of India using the crop simulation models, suggest that rainfed rice yields are projected to reduce by 20 % in 2050 and 47 % in 2080 scenarios. Climate change is projected to reduce wheat yield by 19.3 % in 2050. K*harif* maize yields are likely to be affected by 18% in 2050.

Across the world, the agriculture sector needs to boost crop productivity while at the same time bringing more sustainable solutions to the market that are more effective and highly targeted.

Similarly, there have been changes in pest and disease patterns which need more innovations and sustainable solutions. India's population is projected to reach approximately 1.66 billion by 2050 and the global population is on track to reach 9.7 billion. Thus, farmers worldwide need to grow more food while reducing their impact on the environment and safeguarding natural resources. Working alongside farmers, we believe agriculture can be a solution to tackling the climate change.

Fostering Innovation

With our extensive research and development infrastructure, our global scale and cutting-edge science, we empower farmers with the required tools and enable them to keep feeding the world, now and into the future. For example, Tymirium, a Syngenta trademarked active ingredient, gives broad-spectrum protection against nematodes and key fungal diseases. It is a great example of Syngenta investing in innovation to provide farmers with tools that help them maximize their yield in a sustainable way.

Across the world, the agriculture sector needs to boost crop productivity while at the same time bringing more sustainable solutions to the market that are more effective and highly targeted. Embedding a 'safe by design' concept across all stages of the crop protection product lifecycle, we focus on developing formulations that minimize the potential for exposure. We also embrace digital technologies, including precision agriculture and remote monitoring, to foster more sustainable agriculture practices.

By adopting regenerative agriculture practices such as cover crops, no-till techniques and precision application of chemical and biological inputs, farmers are helping to mitigate the impact

About the **AUTHOR**

Susheel Kumar is the Country Head & Managing Director of Syngenta India Pvt Ltd

of climate change on their land. They can also protect biodiversity and natural habitats by sustainably increasing productivity on their existing farmland. Syngenta invests in research to understand how beneficial practices can be applied efficiently in local settings and into various products to be used on-farm that maximize soil health, yields, and carbon capture. Bio stimulants improve carbon sequestering capacity, nutrient uptake, and overall resilience to climate effects such as heat and drought.

Mitigation and Adaptation

As a global leader in agriculture technology and innovation, we are relentless in our efforts to reduce the impact of agriculture on the environment. We are exploring options for renewable electricity sourcing, energy conservation and decarbonization, and reducing energy consumption, water and waste intensity across our production sites. To improve our carbon footprint in supply chain, globally, we are working with suppliers to make our manufacturing processes more efficient and identify opportunities for decarbonization.

We must note that the escalating challenges posed by rising temperatures, extreme weather events, and shifting precipitation patterns demand proactive adaptation and the development of resilient crop varieties. Sustainable agricultural practices, precision farming, and responsible water management are essential to mitigating the climate crisis's impact on agriculture. A changing climate disrupts growing seasons, water availability, and crop productivity, posing significant challenges to farmers striving to meet the food demands of a growing population.

Investing in research and development (R&D), disseminating climate-smart agricultural practices, and leveraging innovative technologies are crucial steps toward mitigating greenhouse gas emissions and equipping farmers to adapt effectively. Techniques such as minimum tillage, crop rotation, and efficient nutrient management optimize resource use and reduce soil-based carbon emissions. Additionally, promoting permanent crop cover strategies can transform agricultural fields into carbon sinks, helping sequester carbon dioxide from the atmosphere.

Agriculture - Leading Climate Mitigation Efforts

Moreover, collaboration among farmers, both large and small, along with other stakeholders in the food supply chain, fosters a holistic approach to knowledge transfer and tangible progress in sustainable agriculture. Advancing sustainability initiatives will position agriculture as a pivotal force in combating climate change. Enhancing manufacturing efficiency, implementing energy-saving programs, and increasing reliance on renewable energy further contribute to climate action.

Innovations empower farmers to optimize resource use, monitor crop health, and adapt to changing weather patterns. Smart irrigation systems help conserve water, a critical necessity in the face of unpredictable rainfall and prolonged droughts, while climate-resilient crop varieties bolster food security by withstanding extreme weather conditions. Data analytics and machine learning enable farmers to make informed decisions, improving productivity while minimizing environmental impact. Farm digital passbook also helps in keeping a track of on-farm crop protection products usage for better traceability.

Similarly, unmanned aerial vehicles (UAVs) facilitate rapid field assessments, identifying pest infestations and disease outbreaks before they escalate. By harnessing cutting-edge technology, agriculture can not only adapt to climate challenges but also become a proactive force in sustainable food production. Engaging with supply chain partners to establish carbon reduction targets and implement sustainable measures is vital, given the sector's significant carbon footprint.

Policy-driven initiatives such as government subsidies, MSP reforms and climate adaptation programmes, will further provide a structured framework for long-term agricultural sustainability.

Providing farmers with access to climate-smart agricultural techniques, advanced technologies, and targeted training equips them to navigate evolving environmental conditions effectively. Access to climate information and early warning systems enables informed decision-making, reducing risks associated with extreme weather events. Financial incentives and support mechanisms for adopting eco-friendly practices further encourage the agricultural sector to lead in climate mitigation efforts.

Way Forward

A collaborative approach – integrating knowledge exchange, technological support, and policy-driven initiatives – will play a crucial role in empowering farmers. Given the agriculture sector's dependence on monsoons, smallholder farming dominance, and evolving market dynamics, such an approach enhances resilience against climate change, fluctuating prices, and resource constraints.

Knowledge exchange through farmer training programs, agri-extension services, and digital platforms helps disseminate best practices, scientific advancements, and sustainable farming techniques. Technological support, including precision farming, AI-driven analytics, and improved irrigation methods, enables farmers to optimize resources, enhance productivity, and mitigate risks.

Policy-driven initiatives such as government subsidies, MSP reforms and climate adaptation programmes, will further provide a structured framework for long-term agricultural sustainability. Indian agriculture has immense potential to transition towards a more sustainable and climate-resilient future, ensuring food security, economic stability for farmers, and environmental conservation in the face of growing challenges.

REJUVENATION OF SOIL HEALTH IN AGROECOSYSTEMS OF INDIA UNDER CHANGING CLIMATE

Climate Change and India's Agriculture

Climate change is a major factor which will continue to be strong determinant of India's agricultural productivity. Crop yield and productivity in India are strongly vulnerable to rising temperatures, changing rainfall patterns and amount, increasing frequency of extreme events such as drought/flood syndrome, and even more importantly degrading soils and desertifying lands of agroecosystems. According to some estimates, agricultural productivity may decrease strongly from 2030 with strong adverse impact on GDP. However, agriculture is both culprit and victim of changing climate because it aggravates climate change by emission of major greenhouse gases (CO_2, CH_4 and N_2O), and is in turn also vulnerable to changing and uncertain patterns of rainfall, extreme drought, heat wave, and falling water tables. Soil degradation creates a positive feed-back to climate change and is aggravated by extreme events. Soil degradation and climate change are mutually reinforcing processes, especially in semiarid and arid regions of India.

Climate Change in Relation to Soil Degradation and Land Desertification in India

Soil degradation and land desertification, serious issues in several of India's agroecosystems, are being aggravated by changing climate, and affecting about 30 % of the land area. Soil degradation , caused by anthropogenic factors , is set-in-motion by deforestation and denudation of sloping lands, excessive plowing and flood-based irrigation of croplands,

Soil degradation and land desertification, serious issues in several of India's agroecosystems, are being aggravated by changing climate, and affecting about 30 % of the land area.

indiscriminate and unbalanced use of fertilizers (178 kg/ha in India vs.113 kg/ha in the world), excessive use of pesticides (0.25 kg/ha), in-field burning of crop residues (200 M ton /yr), and uncontrolled grazing of livestock. These practices also lead to emissions of greenhouse gases which are aggravating the climate change while increasing risks of natural disasters such as flooding of the Indo-Gangetic plains during the monsoon season.

About the **AUTHOR**

Rattan Lal
CFAES Rattan Lal Center for Carbon Management and Sequestration, The Ohio State University, Columbus, Ohio, USA

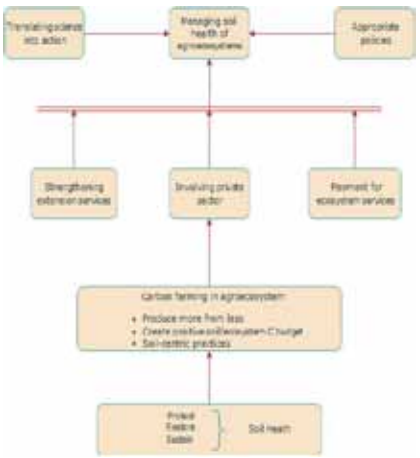
Estimates of soil degradation in India by NAAS/ICAR and other studies indicate land area (M ha) affected by water erosion at 64 (vegetation denudation of 40), wind erosion at 9, water logging at 14, salinization at 7, acidification at 16 and other processes at 7.These estimates do not include several other factors of soil degradation such as depletion of soil organic matter (SOM) content , topsoil removal by brick making, and mining of nutrients such as P,K,Ca,Mg,and micronutrients which are being removed but not replaced because of unbalanced use of fertilizers. Soil organic matter content in the top 20 cm layer of croplands in northwestern region of India may be < 0.25% compared with an optimal level of 1.5 to 2.5%. Thus, soil health is degraded , nutritional quality of food produced is jeopardized, water quality and renewability is adversely affected, air quality is polluted, biodiversity is dwindled, and anthropogenic global warming is being severely aggravated.

The problem lies in misuse of technology because of over-fertilization and unbalanced fertilization, indiscriminate use of pesticides, use of excessive and flood based irrigation, undertaking an un-necessary and excessive plowing, and choosing uncontrolled grazing and in-field burning of crop residues. These practices, which have increased soil/environmental degradation and aggravat-

ed anthropogenic climate change, are often promoted by inappropriate policies, which need to be critically reviewed and urgently revised.

Transforming India's Agriculture From Problem into a Part of the Solution for Mitigation/Adaptation of Climate Change and Restoring the Environment

Transformation of India's food systems can be set-in-motion by :1) protecting quality of soil and biophysical environment,2) promoting negative emission technologies (NET) in all agroecosystem,3) adopting carbon farming, and 4) creating policies which are pro-nature, Pro-agriculture and pro-farmers. The schematic in Figure 1 show strategies of managing soil health of agroecosystems by transforming science into action by identifying and implementing appropriate policies which are aimed at: a) strengthening of extension services, b) involving private sectors ,and c) motivating farmers through payments of ecosystem services which are strengthened by innovative farming practices. The choice of site/soil specific practices would include on the basis of principles of: a) producing more from less, b)creating a positive soil /ecosystem C budget, and c) adopting a soil -centric approach. Implementation of these 3 principles will enhance SOM stock over a decadal scale aimed at protecting, restoring and sustaining soil health (Figure 1).



A schematic of managing soil health in agroecosystems of India

Soil Health Act

Because access to an adequate amount of safe and nutritious food is the most basic human right of each inhabitant of the planet Earth, there is an urgent need to develop policies which are pro-nature, pro-agriculture and pro-farmer so that no farmer/rancher (small ,medium or large land holder)is left behind. The schematic in Figure 2 show that maintaining an optimal level of soil health is critical to improving air quality, water quality and renewability, activity and species diversity of above and below-ground biodiversity, ecosystem and human health. Soil organic matter content, being the heart of soil health, must be maintained at an optimal level of 1.2 to. 2.5% in the root zone (0-30 cm depth) by regular input of biomass carbon into the soil. Furthermore, soil surface must be always protected against natural and anthropogenic perturbations by adopting conservation agriculture involving complex rotations, integrated nutrient management (INM) and integrated pest management (IPM) and maintaining a continuous ground cover on the soil surface.

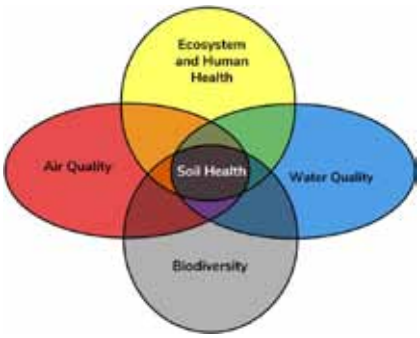


Figure 2. Innovataive policies are needed for protection, restoration, and sustainable management of soil functions to enhance ecosystem and human health by improving air quality, water quality and renwabiility , and strengthening biodiversity such as activity and species diversity of above and below ground bioata.

Carbon Farming and Soil Health Act

The term carbon farming means growing carbon in land (soil and wooded biomass) which can generate another income stream for farmers.In other words,it is commodification of carbon grown on land which is a source of income. It would inolve adoption of practices such as conservation agriculture (no-till,retention of crop residue mulch on the surface, use of integrated nutrient management or INM and integrated pest management or IPM, and growing crops in a system that integrates grain crops with trees and livestock. There is a need to establish and use Soil Health Act with the provision of rewarding farmers for growing carbon at the rate of US$50 per credit (one metric ton of CO_2 equivalent). Similar to carbon credit, there may also be an opportunity to water credit for conserving and saving of water in the root zone.

Climate change is a major factor which will continue to be strong determinant of India's agricultural productivity.

A Soil-Centric Green Revolution

Improved varieties of crops and of livestock are important to enhancing quality and quantity of food production and promoting nutrition-sensitive agriculture. But the benefits of improved germplasm can only be realized if grown/raised on healthy soils .Soil health has five distinct but related/interacting components;pysical,chemical, biological,pedological and ecologicical. The heart of soil health for mineral soils ,affecting all components and their dynamics, is soil organic matter(SOM) content. An optimal level of SPM content for arable land may be 2 to 3 % in the top 0-20 cm layer. Most cropland soils of India are severely depleted of their SOM content,, which may be as low as 0.25 % in the north western regions . Thus, there is a strong need to restore SOM content by adoption of practices which prmote regular input of biomass-C.

REGENERATING INDIA'S FIELDS AND FUTURE GROWTH THROUGH SUSTAINABLE AGRICULTURE

As climate pressures intensify and food security challenges loom, India's agricultural sector stands at a crucial juncture. Now, more than ever before, the need for scalable, climate-smart solutions cannot be refuted. Bayer, through its integrated sustainability and innovation initiatives, is stepping up with a clear ambition: to reimagine agriculture by anchoring it in regenerative practices and carbon accountability.

Regenerative Agriculture

At the heart of Bayer's regenerative agriculture drive in India is a fundamental shift in how rice is grown. Rice farming, long associated with water intensity and high emissions, is being transformed through practices like Direct Seeded Rice (DSR). These practices form the core of Bayer's ForwardFarm program in India—a model farm initiative that demonstrates cutting-edge agronomic techniques for sustainable production.

DSR alone can reduce water usage by 30–40%, lower greenhouse gas emissions by up to 45%, and ease labour requirements by as much as 50%. This is not just sustainability in theory, but regeneration in action.

The ForwardFarm platform connects farmers, researchers, and ecosystem partners to scale these benefits—ensuring that the transition is practical, profitable, and farmer-centric.

Spread over 18 hectares, the Bayer

About the **AUTHOR**

Mohan Babu is the Commercial Lead for India in the Crop Science Division of Bayer

ForwardFarm in India is unique as it introduces a convergence of innovative technologies and sustainable interventions specifically designed for smallholder farmers. The farm integrates the following practices:

- **Direct Seeded Rice (DSR) Cropping System:** A sustainable alternative to traditional rice cultivation that minimizes soil disturbance, reduces water consumption, and enhances soil health.
- **Innovative Weed Management:** Advanced weed control strategies that reduce reliance on chemical herbicides while maintaining crop health.
- **Customized Agronomy Systems:** Tailored solutions for diverse climatic conditions and soil types, enhancing crop yields and soil health.
- **Carbon Farming:** Practices aimed at capturing and storing carbon in the soil, contributing to climate change mitigation and soil fertility improvement.
- **Nutrition and Water Management:** Advanced techniques to optimize nutrient use and water efficiency, boosting farm productivity while reducing environmental impact.
- **Vermicompost and IoT:** Use of vermicompost to enhance soil health, coupled with IoT technologies for precise monitoring and management of agricultural processes.
- **Irrigation and Drone Technology:** Innovative irrigation techniques and drone technology for optimized water use and precise crop management.

Rice farming, long associated with water intensity and high emissions, is being transformed through practices like Direct Seeded Rice (DSR).

In addition to the work being done at the ForwardFarm, Bayer is also actively promoting awareness and education on zero or low tillage practices across various crops, including horticulture crops, through its Bayer Learning Centers.

Turning sustainability into currency

Building on these on-ground innovations, Bayer has taken a landmark step by issuing its first tranche of carbon credits from Indian rice farmers implementing DSR and other regenerative practices. These credits—amounting to up to 250,000 tonnes of CO☐ equivalent—are being validated and certified by Gold Standard, one of the world's most rigorous frameworks in the voluntary carbon market.

The move validates the climate-positive impact of Bayer's interventions and introduces a new income stream for smallholder farmers. By monetizing emission reductions, farmers can now access financial incentives previously out of reach—further reinforcing the case for regenerative agriculture at scale.

Strengthening impact through collaboration

This push doesn't exist in isolation. Bayer is a leading partner in The Good Rice Alliance (TGRA), a collaborative platform designed to drive sustainable rice production globally. TGRA is designed to accelerate the adoption of practices like AWD and DSR, while also setting up systems for transparent measurement, reporting, and verification of carbon outcomes.

Initiatives like The Good Rice Alliance, where private players like Bayer, GenZero, Shell, and Mitsubishi have

joined hands to empower rice farmers, demonstrate the transformative potential of partnerships. The alliance is achieving over 100,000 tonnes of CO2-equivalent methane emission reductions annually by promoting climate-smart practice; and has positively impacted 10,000 farmers, covering over 25,000 hectares.

Such partnerships emphasize corporate responsibility and the necessity of a collaborative effort to drive agricultural sustainability successfully. By combining technological innovation with farmer empowerment and credible carbon credit systems, such alliances pave the way for a climate-smart agricultural future. As these initiatives scale, the convergence of sustainable farming and carbon advocacy has the potential to drive lasting environmental impact while reshaping rural economies globally.

By aligning with other industry leaders, Bayer is helping build the trust, systems, and scale needed for the global voluntary carbon market to thrive—particularly in geographies like India, where smallholder engagement is key.

Fuelling clean energy

While Bayer's regenerative agriculture and carbon programs are focused primarily on soil health and emission reductions, they also contribute indirectly to the clean energy movement. By creating carbon credit ecosystems in agriculture, financial capital can be redirected into sustainable fuel initiatives—such as corn-based biofuel programs—that close the loop between agriculture and energy. It's an ecosystem view that acknowledges the interdependence between climate-smart crops and future energy security. In a country like India, which is striving for greater energy self-sufficiency and currently bears a significant crude oil import burden, such integrated efforts can play a critical role in reducing reliance on fossil fuels and fostering homegrown alternatives. At the same time, these initiatives support farmers by helping them increase yield per acre and earn more through both improved productivity and participation in emerging green value chains.

By creating carbon credit ecosystems in agriculture, financial capital can be redirected into sustainable fuel initiatives—such as corn-based biofuel programs—that close the loop between agriculture and energy.

Empowering Smallholders

At the center of all these innovations is the smallholder farmer. Through programs like DirectAcres, farmers gain access to holistic crop solutions—seeds, crop protection, digital tools, and advisory services. The program helps them lower input costs, reduce risk, and boost yields. And now, with carbon credit earnings in the mix, farmers are also becoming stakeholders in a global climate solution.

Empowering these farmers with new market linkages, incentive systems, and sustainable practices is an investment in the resilience of India's food systems. It's also a step toward correcting market asymmetries that have historically left smallholders behind.

Looking ahead: India as a lighthouse for agricultural decarbonization

Bayer's entry into the global carbon market via Indian rice fields signals a new chapter where climate finance, regenerative agriculture, and rural livelihoods converge. It's a model that proves sustainability can be both scalable and equitable—and that corporate actors have a meaningful role to play in shaping this future.

As global climate goals inch closer and carbon accountability becomes non-negotiable, India has the opportunity to become a lighthouse market for agricultural decarbonization. With Bayer's continued leadership, and alliances like TGRA building momentum, regenerative agriculture is now becoming a reality that is rooted in science, built on partnerships, and driven by farmers.

REIMAGINING INDIAN AGRICULTURE IN A CHANGING CLIMATE

BUILDING RESILIENCE FOR A SUSTAINABLE FUTURE

Across the vast and diverse landscape of India, agriculture is far more than an economic activity—it is a way of life, culture, and sustenance for millions. However, this vital sector now finds itself at a crossroads. Over the past few years, farmers have been navigating a reality where seasons shift unpredictably, rainfall patterns defy traditional forecasts, and extreme weather events strike with greater frequency. What was once occasional has now become routine: sudden droughts, unseasonal downpours, and scorching heatwaves that disrupt sowing and harvest cycles. These changes are no longer distant possibilities—they are happening here and now, shaping the future of agriculture in India.

Technology has revolutionized farming in the face of climate uncertainty. Precision agriculture, guided by AI-based climate models and IoT devices, allows for optimal resource use.

Agriculture continues to support nearly 60% of India's population, contributing significantly to employment and food production. Yet, its deep reliance on climate-sensitive resources like water and soil makes it particularly vulnerable. For instance, rising temperatures in wheat-growing regions of Punjab and Haryana have been linked to declining yields. For example, in 2022, India's wheat production dropped to 106.84 million tonnes, down from 109.59 million tonnes in 2021, largely due to a 45-day extreme heatwave in March–resulting in domestic supply challenges and impacting international grain markets. In Maharashtra, over 5.6 million hectares of agricultural land were affected by unseasonal rains in 2023. Similarly, Assam lost 19% of its sown paddy due to delayed and erratic monsoons. The increasingly unpredictable monsoon, once a dependable lifeline, has become a source of uncertainty.

These disruptions also have ripple effects on food security and inflation. Key staples like rice and vegetables now face unpredictable supply, triggering price volatility. For instance, tomato prices surged over 300% in mid-2023 due to floods in southern India that damaged crops.

A brief but intense heatwave can shrink yields; a delayed monsoon can alter sowing plans for millions. According to the Indian Meteorological Department (IMD), 2024 was the warmest year on record in India since 1901—conditions that significantly impact agricultural output and labour productivity.

In the global context, climate-in-

About the **AUTHOR**

Dr Vibha Dhawan is the Director General, The Energy and Resources Institute (TERI). The Energy and Resources Institute (TERI) is an independent, not-for-profit, knowledge-driven institute dedicated to advancing transition towards a cleaner and sustainable future.

duced disruptions are intersecting with shifting geopolitical dynamics around food security. As countries respond to climate-related production shortfalls with trade restrictions and export bans, India's policy decisions—such as temporary limits on rice and wheat exports to stabilize domestic prices—have far-reaching implications on global supply chains. While such measures are aimed at protecting local consumers, they also underscore the growing tension between national food priorities and international trade expectations.

Adaptation Strategies: Building Climate-Resilient Agriculture

To enhance resilience, the adoption of climate-smart agricultural methods is essential. These include innovative farming practices, policy support, and behavioural change.

Climate-smart agriculture (CSA) emphasizes sustainable practices that maintain productivity under climatic stress. One approach involves cultivating drought- and heat-resistant crop varieties, such as climate-resilient rice such as DRR Dhan 42, a climate-resilient rice variety, and drought-tolerant HHB 67 Improved bajra (pearl millet) in Rajasthan.

Water conservation techniques like drip irrigation, rainwater harvesting, and aquifer recharge have gained traction in water-scarce states like Rajasthan and Maharashtra. Agroforestry and mixed cropping systems are also being promoted to preserve soil integrity and biodiversity.

Technology has revolutionized farming in the face of climate uncertainty. Precision agriculture, guided by AI-based climate models and IoT devices, allows for optimal resource use. Farmers can now use mobile applications for weather updates, enabling better decision-making regarding sowing and harvesting. Drones and satellite imagery also aid in monitoring crop health and managing pest outbreaks more efficiently.

India's Long-Term Low Emissions Development Strategy (LT-LEDS) outlines a pathway for sustainable agricultural transformation, focusing on low-carbon technologies, energy-efficient machinery, and diversified cropping systems.

Policy interventions and financial tools are critical for supporting farmers. Government-backed crop insurance schemes help mitigate losses due to climatic events. Subsidies for climate-resilient technologies and extension services to train farmers in sustainable practices are equally important. The National Mission on Sustainable Agriculture (NMSA) and initiatives like Paramparagat Krishi Vikas Yojana (PKVY) are promoting climate-resilient practices, including organic farming, integrated pest management, and improved irrigation. In Andhra Pradesh, natural farming practices are gaining momentum, reducing dependency on synthetic inputs while improving soil health and biodiversity.

Water management is also receiving renewed focus. Micro-irrigation systems, farm ponds, and rainwater harvesting projects under schemes like Pradhan Mantri Krishi Sinchayee Yojana (PMKSY) are enabling more efficient use of water, especially in semi-arid regions such as Gujarat and parts of Karnataka.

Promoting Behavioural Shifts: The Case for Millets

In recognition of the need for dietary diversification and sustainable farming, the United Nations declared 2023 as the International Year of Millets. Millets, which are hardy, nutrient-rich, and require significantly less water than rice or wheat, offer a promising adaptation solution for climate-resilient agriculture. India, traditionally a millet-growing nation, has revived its focus on these crops through initiatives like the "Millet Mission" in states like Karnataka and Odisha. The "Millet Mission" has led to a 143% increase in procurement of millets by government agencies between 2021–2023, improving farmer incomes.

By encouraging a dietary shift toward millets, consumers contribute to reduced pressure on water-intensive crops, while farmers benefit from improved income due to higher market demand. Moreover, millet cultivation enhances soil health and reduces the carbon footprint associated with conventional grains, aligning well with broader climate adaptation goals.

Millets are also gaining attention for their health benefits. With a low glycaemic index, they help regulate blood sugar levels and are particularly suitable for people with diabetes and lifestyle-related disorders. Varieties such as foxtail millet and barnyard millet are known to improve insulin sensitivity and promote satiety, making them ideal for diabetic-friendly diets.

Mitigation Strategies: Lowering Agriculture's Environmental Impact

Mitigation strategies are equally important. Agriculture is a notable source of greenhouse gas emissions—methane from rice paddies and livestock, and nitrous oxide from fertilizers.

Recognizing this, the Government of India has launched the PM-PRANAM (PM Programme for Restoration, Awareness, Nourishment and Amelioration of Mother Earth) scheme to promote the balanced use of chemical fertilizers and encourage the adoption of alternative, eco-friendly nutrients. Under this initiative, states are incentivized to reduce their chemical fertilizer usage, with a share of the savings directed toward promoting sustainable practices. India has also become the first country in the world to officially approve the use of nano-fertilizers, which hold significant promise in cutting down fertilizer-related emissions while improving nutrient efficiency and restoring soil health.

Biogas units and composting systems are being scaled to manage agricultural waste and reduce dependency on chemical fertilizers. Pilot initiatives in Karnataka are testing feed additives like Asparagopsis (red seaweed) to cut methane emissions from cattle by up to 30%.

India has also become the first country in the world to officially approve the use of nano-fertilizers, which hold significant promise in cutting down fertilizer-related emissions while improving nutrient efficiency and restoring soil health.

These innovative formulations, such as nano urea, require smaller quantities for the same effect, thereby reducing leaching, water pollution, and greenhouse gas emissions. Taken together, these initiatives are paving the way for a more climate-resilient and environmentally sustainable agricultural model.

Way Forward

Looking forward, India's Long-Term Low Emissions Development Strategy (LT-LEDS) outlines a pathway for sustainable agricultural transformation, focusing on low-carbon technologies, energy-efficient machinery, and diversified cropping systems. The introduction of the Green Credit Programme could further incentivize farmers to adopt sustainable practices, with potential benefits for both livelihoods and ecosystems. Through platforms like the G20, and South-South Cooperation, India is sharing best practices in solar irrigation, resilient cropping, and agroecology with other developing nations.

TERI 2021 report on sustainable agriculture highlighted that every Rs. 1 invested in natural farming yields a Rs. 3–4 social return, owing to improved soil health, water efficiency, and ecosystem restoration. However, challenges remain. Smallholder farmers often lack the financial cushion to absorb losses or invest in adaptive technology. Strengthening credit systems, crop insurance, and on-ground extension services is essential to ensure that climate resilience is inclusive. Equally important is investment in agricultural research—developing stress-tolerant crop varieties, promoting agroforestry, and integrating traditional wisdom with modern science. Ultimately, securing the future of Indian agriculture will require sustained commitment from all stakeholders—farmers, researchers, policymakers, private sector, and the civil society. The climate challenge, while significant, also presents an opportunity to redefine how we grow, distribute, and consume food in a way that is ecologically balanced, socially inclusive, and economically viable.

India's agricultural resilience story is still being written—and with the right mix of innovation, collaboration, and vision, it can become a global example of how to thrive in the face of uncertainty.

CLIMATE RESILIENCE IN AGRICULTURE

Through Seeds, Science, and Sustainability

As climate change threatens to upend traditional farming systems, a powerful solution is quietly emerging from the soil itself, **seeds infused with science, strengthened by biotechnology, and guided by sustainability**. These seeds are not just the beginning of the food cycle, they are the first line of defence against a warming world.

Biotechnology is no longer a futuristic concept; it is today's most promising answer to a climate-stressed agricultural sector. India, with its scientific capabilities, farmer base, and rich biodiversity, is uniquely positioned to lead a new green revolution, one that is resilient, inclusive, and regenerative. India's vulnerability to climate change is most visible on its farmlands. Frequent droughts, erratic rainfall, unseasonal floods, and heatwaves are no longer anomalies. They are the new normal. Over the past decade alone, the country has lost nearly 69 million hectares of agricultural land to extreme weather events; 33.9 million to excess rainfall and 35 million to drought.

Small and marginal farmers, who constitute 86% of India's 146 million operational holdings, bear the brunt. With an average landholding of just 0.38 hectares, their ability to absorb shocks is minimal. Climate change is not just reducing yields, it is increasing input costs, disrupting livelihoods, and pushing communities to the edge. India, however, is not responding with despair. It is responding with science.

Seeds of Resilience: Biotechnology as Climate Strategy

The climate crisis demands agricultural solutions that are fast, scalable, and effective. Biotechnology offers precisely that. Advanced seed technologies, including hybrids, transgenic crops, and gene-edited varieties, can empower farmers with crops that tolerate drought, survive salinity, withstand pests, and thrive in high temperatures. They reduce dependence on chemical inputs, preserve soil and water, and ensure stable yields even in erratic conditions.

The IPCC warns that every 1°C rise in temperature could cut wheat yields by 6% and rice yields by 3%, a catastrophe in a country where over 50% of the population depends on farming.

We've seen the success story of Bt cotton, a single biotech intervention that transformed India into the world's largest cotton producer while reducing pesticide usage. That same potential exists across

About the **AUTHOR**

Ajai Rana is the Chairman, Federation of Seed Industry of India (FSII) and CEO & MD of Savannah Seeds

other crops, including maize, rice, pulses, and oilseeds. India must now widen the scope of this success.

Complementing biotech is the rise of climate-smart agronomic practices like Direct Seeded Rice (DSR), a method that eliminates the need for nursery transplanting and continuous flooding. DSR reduces water consumption by up to 30%, lowers labour costs, and significantly curbs methane emissions, a potent greenhouse gas.

However, for DSR to reach its full potential, it needs precision-bred, weed-competitive, short-duration rice varieties that germinate uniformly and can tolerate early-season stress. This is where seed innovation becomes indispensable. Biotechnology can accelerate the development of such DSR-compatible varieties, making the practice more accessible and effective for millions of Indian rice farmers.

Science at the Centre of Sustainability

For India, climate action is not optional, it is foundational to growth. The country's development model has consistently aligned economic ambition with environmental consciousness. Despite being the world's fifth-largest economy, India's per capita carbon emissions remain a third of the global average. Our **Net Zero 2070** commitment reflects a vision where growth and green goals go hand in hand.

In this context, agriculture, which contributes around **14% of India's greenhouse gas emissions**, must evolve into a climate solution rather than a climate victim. Seeds play a pivotal role in this transition.

A high-yielding, climate-resilient seed variety tailored for DSR reduces land pressure, irrigation needs, fertilizer use, and carbon emissions per kilogram of output. It enhances productivity without environmental compromise. That is **sustainability by design**, not as an afterthought.

Policy Momentum Meets Scientific Promise

The Economic Survey 2023-24, in its chapter on *'Climate Change and Energy Transition: Dealing with Tradeoffs'*, reinforces India's dual-track approach, mitigating climate risks while advancing livelihoods.

Climate resilience must not remain the reserve of the progressive few, it must be the right of every farmer.

The agricultural sector is central to this vision.

India has already created a carbon sink of 1.97 billion tonnes through afforestation and ecosystem restoration from 2005–2019. The next frontier is carbon-smart agriculture, driven by biotech-enabled crops and sustainable practices.

Technologies like CRISPR-based gene editing allow rapid development of stress-resilient varieties without foreign DNA insertion, making them more acceptable and adaptable. Globally, countries like the Philippines, Brazil, and the USA have embraced such technologies to improve food security and climate adaptation. India must follow suit, with progressive regulation and strong public-private partnerships.

The IPCC warns that every 1°C rise in temperature could cut wheat yields by 6% and rice yields by 3%, a catastrophe in a country where over 50% of the population depends on farming. Already, we are seeing signs of declining yields in our staple crops. This is not just a food crisis, it's a national security concern. However, Biotechnology can change the equation.

Imagine rice varieties that flower early to escape terminal heat, maize that survives drought, mustard that withstands early-season stress, and pulses that resist pod borers, all possible, all in development, and many already tested. What's needed is facilitation, not hesitation.

From Innovation to Impact: Empowering Every Farmer

For biotech solutions to be inclusive, they must be accessible to India's smallest farmers. This means not just seed availability, but also training, credit access, extension services, and policy support. Climate resilience must not remain the reserve of the progressive few, it must be the right of every farmer. We must create a national mission that accelerates biotech adoption, backed by science communication and community engagement.

India's story has always been one of transformation, from food scarcity to self-sufficiency, from bullock carts to drones. Today, as the climate challenge looms large, the next chapter of this story must be written in the language of biotechnology, sustainability, and science-driven agriculture. The seed industry is ready. The science is ready. And most importantly, India's farmers are ready, to adopt, adapt, and thrive. All they need is a system that believes in their potential and gives them the tools to succeed.

GREEN FINANCE FOR RURAL INDIA

Unlocking the Potential of Climate Funding

Rural India lies at the core of the India's transformation, playing a vital role in both livelihood generation and overall economic development. With nearly 64% of the population residing in rural India, it serves as the backbone of agriculture, a sector that employs over 45% of the country's workforce. In addition to agriculture, allied sectors such as animal husbandry, forestry, fisheries, and rural manufacturing remain crucial to ensuring food security, driving exports, and promoting inclusive growth. However, the growing impacts of climate change are adversely reshaping this landscape - loss of soil fertility, intensified pests and diseases occurrences leading to yield and livestock losses, thereby threatening the livelihoods of rural communities. Prolonged warming and growing irrigation needs have intensified the overuse of critical water resources across rural India. In this context, green finance has emerged as a vital lever to build the resilience of rural livelihoods against the escalating impacts of climate change.

Strategic investments in climate-resilient agriculture, soil and water conservation, watershed development, and drought-proofing initiatives can enhance productivity while safeguarding natural ecosystems. By unlocking capital for these interventions, green finance can enable rural India to transition toward a more sustainable, adaptive, and resource-secure development trajectory.

Despite threefold increase in adaptation finance flows during 2021-22, reaching USD 15 billion (INR 1,092 billion) annually, the climate adaptation sectors remain significantly under financed.

About the **AUTHOR**

Sanjeev D Rohilla is the Chief General Manager, NABARD

Adaptation Finance is Vital for Rural India

Without adequate investments in adaptation projects that focus on promoting climate-resilient crops, water conservation systems, early warning mechanisms, and resilient infrastructure, the rural community will be left increasingly vulnerable. Despite threefold increase in adaptation finance flows during 2021-22, reaching USD 15 billion (INR 1,092 billion) annually, the climate adaptation sectors remain significantly under financed. India needs an estimated USD 1 trillion (INR 85.6 trillion) in adaptation investments by 2030, underscoring the urgent need to scale up climate adaptation finance to avert severe climate impacts. Currently, climate mitigation sectors including clean energy, clean transportation, and energy efficiency attract most of the green finance- driven by conducive government's policies, viable revenue models, measurable economic returns. In contrast, adaptation sectors face persistent barriers including absence of robust adaptation finance frameworks, limited economic returns and lack of well-structured and investment ready adaptation projects. Hence, addressing the adaptation financing gap is essential to safeguard rural communities from impending climate risks, build their resilience, and to ensure sustainable and inclusive rural development.

Sector Wise Green Finance Share

India's green finance landscape has made steady progress, with domestic

sources continuing to play a dominant role in funding both mitigation and adaptation finance. While the private sector contributes significantly to the domestically tracked mitigation finance (USD 28 billion or INR 2,048 billion), it's role in mobilizing adaptation finance remain limited. Currently 98% of domestically tracked adaptation finance is sourced from central and state government budgets, with domestic private equity and venture capital funds contributing to less than 1% to on-farm adaptation activities. Moreover, the green finance ecosystem is still largely reliant on traditional financial instruments such as debt, equity, and grants, with limited deployment of innovative tools such as blended finance, guarantees, or outcome-based financing models. Unlocking greater private sector participation and mainstreaming innovative financing approaches will be key to closing the adaptation finance gap and building climate resilience at scale.

Challenges

Green financing in rural India is constrained by several structural and operational barriers that limit its scale, effectiveness, and impact. The critical challenges impeding wider deployment of green finance include:

- ***Lack of viable and bankable models:*** Climate-resilient interventions such as agroforestry, organic farming, and waste-to-value projects are often fragmented, localized, and lack standardization. Their small scale and long gestation periods make it challenging to aggregate them into financially viable, bankable propositions that can attract mainstream investment.
- ***High upfront costs and limited affordability:*** The adoption of green and low-carbon technologies such as solar irrigation systems, bio-digesters, and energy-efficient farm machinery is often constrained by high initial investment requirements. In the absence of accessible, affordable financing solutions tailored to requirement, these technologies remain out of reach for most farmers and rural enterprises, limiting their large-scale deployment.
- ***Limited institutional capacity:*** Rural financial institutions have limited technical capacities to access and manage concessional and blended finance, evaluate green business models and their environmental returns —hindering their ability to mobilize green finance.
- ***Absence of standardized impact metrics:*** The absence of uniform impact measurement frameworks for environmental outcomes, coupled with weak borrower credit profiles and limited risk mitigation instruments, hinders the ability of financial institutions to assess, underwrite, and scale green investments in rural areas. This results in cautious lending behaviour and limited capital flow toward sustainable rural initiatives.

NABARD is uniquely positioned to address the key challenges in scaling green finance in rural India through its extensive partnerships, networks, and institutional capabilities.

NABARD – Driving Green Financing

Overcoming these barriers require innovative financing and de-risking mechanisms, technical assistance and a coordinated effort among institutions like NABARD, state governments, and private capital providers.

NABARD is uniquely positioned to address the key challenges in scaling green finance in rural India through its extensive partnerships, networks, and institutional capabilities. By leveraging its relationships with Regional Rural Banks (RRBs) and other rural financial institutions, NABARD aims to standardize and aggregate fragmented climate-resilient interventions like agroforestry and waste-to-value projects, making them financially viable and attractive to mainstream investment. Through blended finance mechanisms and partnerships with international and domestic sources, NABARD is overcoming high upfront costs by offering affordable, tailored financing solutions for green technologies such as solar irrigation and bio-digesters. Additionally, NABARD is enhancing the technical capacity of rural financial institutions by providing training and tools for evaluating green business models and their environmental returns. By collaborating with stakeholders to develop standardized impact metrics, NABARD is addressing the absence of uniform frameworks, enabling financial institutions to assess, scale, and mitigate the risks associated with green investments, thus unlocking the flow of capital for rural climate-resilient initiatives.

Further, NABARD is strategically driving the green finance in rural India by not only funding green projects under its newly launched NABARD Green Lending Facility (NGLF) but also pioneering innovative financing models in partnerships with institutions like ADB, KfW, GIZ, etc. These organizations enable NABARD to co-develop blended and outcome-based financing mechanisms that combine public finance with commercial capital. These models, equipped with risk mitigation tools, de-risk investments and attract private sector participation in high-risk rural green projects. By leveraging its institutional strengths and strategic partnerships, NABARD aims to unlock significant green capital, accelerating the transition to a more climate-resilient rural economy.

Overall, green finance is a key driver for empowering rural India and fostering a low-carbon future. It has the potential to enhance climate resilience while promoting inclusive, sustainable economic growth. NABARD's role is crucial in mobilizing both domestic and international capital, creating bankable rural green projects, and facilitating collaboration across public and private sectors to accelerate this transition.

Sowing the Seeds of Change

RURAL UPLIFTMENT THROUGH SUSTAINABLE AGRICULTURE

Agriculture has been the backbone of the Indian economy. Its importance has been further solidified through government schemes and CSR initiatives. Over 50% of India's workforce is employed in agriculture, contributing approximately 15-18% to the GDP. The sector is highly diverse, cultivating staple crops such as rice and wheat, and producing cash crops like cotton, tea, and spices. This also supports allied industries, including textiles, food processing, and pharmaceuticals. As Prime Minister Modi stated during his Independence Day address in 2024, "India's heart beats in its fields. The strength of our nation lies in the hands of our farmers."

CSR initiatives are transforming rural agriculture by promoting water and soil conservation.

Yet, on the ground, India continues to witness worrying trends – farmer suicides, child malnutrition, mourning debt and declining agricultural land. In response, India has launched targeted efforts to promote sustainable agriculture in over 100 districts – regions that have historically suffered from low productivity, limited credit access and inefficient cropping skills.

Understanding Sustainable Agriculture

Sustainable agriculture is more than just a shift in technique – it's a strategic movement that prioritizes quality alongside quantity. It embraces ecological balance, economic stability, and long-term resource preservation. Unlike traditional intensification approaches, sustainable agriculture focuses on enriching soil, conserving biodiversity, and reducing the dependency on chemical inputs.

Recognizing this shift, India's Union Finance Minister recently announced a National Mission on High-Yielding Seeds to boost climate-resilient varieties. This shift is timely, as unpredictable rainfall, temperature fluctuations, and pest infestations continue to hurt yields. Through practices such as crop rotation and organic inputs, farmers can reduce pest cycles, improve soil health, and increase resilience to climatic shocks.

Why the Shift is Critical?

Without a transition to sustainable methods, India faces environmental degradation, worsening water scarcity, declining yields, and increased farmer distress. Unchecked use of synthetic fertilizers and excessive groundwater extraction are already contributing to biodiversity loss and greenhouse gas emissions.

Key Practices Driving Sustainable Farming

- Organic farming emphasizes environmental balance by eliminating synthetic fertilizers and pesticides and using environmentally friendly, natural inputs like manure and compost. This method enhances soil health, reduces pollution, and lowers health risks from chemical infusions.
- Crop rotation involves steadily alternating crops on the same land across seasons. This method breaks pest and disease cycles, maintains soil fertility, and reduces pesticides, ultimately promoting healthier and more productive farmland.
- Agroforestry introduces trees into agricultural systems, providing multiple benefits such as increased biodiver-

About the **AUTHOR**

Mr. Paul Abraham, President, Hinduja Foundation

sity, improved soil stability, and diversified farmer income through timber, fruits, and other tree-based products. By creating a balanced ecosystem, agroforestry enhances stability against climate change and naturally controls pests.

- Zero-tillage, or no-till farming, is a method of preventing soil disruption and preserving its quality and fertility. This method reduces erosion, enhances water retention, and supports sustainable agriculture by maintaining soil health.

Government Programmes for Sustainable Agriculture

The Union Finance Minister declared the launch of the programme' Prime Minister Dhan-Dhaanya Krishi Yojana' in collaboration with different states. This sustainable initiative will focus on 100 districts to empower their farmers and their fields. By combining existing schemes and introducing achievable measures, the programme aims to boost productivity, promote crop diversification, and encourage sustainable farming practices.

CSR Initiatives Driving Sustainable Agriculture

Corporate Social Responsibility (CSR) initiatives are necessary for converting traditional agriculture into an eco-friendly, climate-resilient sector. In recent years, MNCS and various corporate companies have invested in sustainable farming techniques and supported various farming projects. CSR-funded research and training programs teach farmers about sustainable practices, reducing their carbon footprint while improving productivity. These initiatives help labourers align with national environmental sustainability and climate adaptation policies, ensuring long-term agricultural viability.

Capacity Building and Farmer Empowerment through CSR

CSR programs transform rural agriculture by equipping farmers with skills, knowledge, and financial literacy to improve productivity and resilience. These initiatives go beyond providing resources. They train farmers in modern techniques, pest management, and efficient resource utilisation, ensuring long-term sustainability.

Sustainable agriculture offers a pathway to achieving long-term ecological stability, economic viability, and social equity by focusing on efficient resource utilisation, enhancing livelihoods, and fostering inclusive growth.

A prime example is the Goat-Based Livelihood Groups (GBLGs) initiative in the Marwar region, where women farmers were trained through structured training and collective support. The CSR initiative organised 15 self-sustaining groups, each receiving training in fodder management, breed improvement, disease prevention, and goat milk-based value-added products like cheese and yoghurt.

Beyond technical training, CSR programs also introduce digital intervention through mobile apps to provide real-time advisory services for farmers, market trends, and weather forecasts, enabling farmers to make informed decisions. Women and smallholder farmers receive micro-financing support and self-help group training, fostering financial Independence and stronger community participation.

CSR initiatives go further in empowering farmers and their families. Some enable them to set up a store to profit from their own produce, enroll their children in schools, and live in the abundance of their sales on the products produced in their fields to avoid dependency.

Water and Soil Conservation Efforts in CSR

CSR initiatives are transforming rural agriculture by promoting water and soil conservation. Companies fund watershed projects, rainwater harvesting, and soil restoration in drought-prone regions to ensure sustainable farming. For instance, in Maharashtra, a CSR-funded program built check dams and recharge wells, reviving dried-up farmlands and restoring groundwater levels.

CSR initiatives partnered by the government have provided water wells/ reservoirs for many villages in India. This need arose when crops failed to survive — either by excessive rainfall or by drought. In many cases, heavy rains caused water to overflow, leading to crop loss, as there were no facilities to store or channel the excess water.

A small-scale cultivator once struggled with poor yields due to water scarcity. The farmer conserves water efficiently and improves soil fertility thanks to CSR-backed and government subsidy drip irrigation and organic composting programs. These initiatives encourage community-led conservation efforts, ensuring long-term sustainability while securing livelihoods. By restoring natural resources, CSR is sowing a future of resilience and prosperity.

Livelihood Diversification and Market Linkages

CSR initiatives encourage farmers to not depend solely on one financial resource. CSR activities strengthen farmers' enrollment in alternative income-generating activities such as beekeeping, poultry, and agro-processing. Farmer-producer organisations (FPOs) and co-operatives are unions established to enhance bargaining power and improve market access.

To sum up, sustainable agriculture is necessary to combat climate change and ensure the resilience of Indian agricultural systems. Sustainable agriculture offers a pathway to achieving long-term ecological stability, economic viability, and social equity by focusing on efficient resource utilisation, enhancing livelihoods, and fostering inclusive growth.

ADAPTATION AND MITIGATION APPROACHES IN AGRICULTURE TO ADDRESS CLIMATE CHANGE

Climate change is no longer just a topic of scientific debate, or a theoretical concept confined to books. It's real and we're feeling, seeing and experiencing its effects firsthand. Climate change is having a profound impact on our planet affecting various aspects of our lives, from the environment to human health, infrastructure, economic growth etc. The Intergovernmental Panel on Climate Change (IPCC) reports states that Earth's average temperature increased by 1.09 degree C from 2011 to 2020 compared to 1850-1900 levels and predicts a 50% chance of reaching or exceeding 1.5 degree C warming even with low GHGs emissions.

While Agriculture contributes to greenhouse gas (GHG) emissions, it is also impacted by the negative impact of increasing GHG emissions, that are the primary driver of climate change. Climate change impacts agriculture through altered temperatures, precipitation patterns, extreme weather events, and shifts in pest and disease dynamics leading to reduced agricultural productivity and altered cropping seasons and patterns.

Few cases in point include shift of apple cultivation to higher altitudes at many places in Uttarakhand and Himachal Pradesh due to warmer temperature. Similarly, orange and apricot cultivation has shifted to 6000 ft. Early blooming of Buransh (Rhododendron) than usual in Uttarakhand has been witnessed due to climate change. Typically, these flower bloom from April to May but in recent years they have started to bloom in February. This could typically cause phenological mismatch between plant flowering and pollinator activity. All these changing patterns can severely compromise the ability of future generations to produce and access food, threatening their food security and well-being.

In India, where agriculture is the backbone of the rural economy, climate-related stresses significantly impact agricultural stability, hence requires need more focused and customized interventions.

About the **AUTHOR**

Himanshu Rattan, Partner and Lead – Food, Agriculture & Allied Services, Government & Public Services, KPMG in India

Another example is of Bihar where unpredicted rainfall, droughts and floods affect crop cultivation. Many districts from Bihar are among the India's most vulnerable to climate change districts. Northern Bihar suffers from annual unexpected late-season floods in Kosi, Bagmati and Gandak rivers destructing Kharif crops, livelihood and infrastructure. Unpredictable monsoon rains in Southern Bihar cause delays in nursery raising, leading to delayed transplanting and reduced rice yield potential.

Scheme Support

The Indian government has implemented several schemes to help farmers adapt to climate change and make agriculture more resilient. Some of the key initiatives are:

- **National Mission for Sustainable Agriculture:** It aims to enhance climate resilience in agriculture through sustainable practices, improving water use efficiency, and promoting organic farming.
- **Paramparagat Krishi Vikas Yojana:** It aims to promote organic farming, providing end to end support to farmers from production to processing, certification and marketing.
- **Bharatiya Prakritik Krishi Paddhati Programme:** It promotes traditional indigenous practices and

creates awareness among farmers about sustainable agriculture methods.

- **National Innovations in Climate Resilient Agriculture (NICRA):** Develop and promote climate resilient technologies in agriculture, addressing vulnerable areas and extreme weather conditions.
- **District Agriculture Contingency Plans (DACPs):** It has been prepared for 651 districts to help farmers to cope with weather aberrations like droughts, floods, and heat waves.
- **Clean Plant Programme:** Aims to transform the horticulture sector by providing access to virus-free, high quality planting material.

Injecting Interventions

Developing nations are more vulnerable to climate change due to their economy relying heavily on climate reliant activities and unequal conditions related to mitigation and adaptation impact. In India, where agriculture is the backbone of the rural economy, climate-related stresses significantly impact agricultural stability, hence requires need more focused and customized interventions. Some of the interventions that could help are outlined below:

- **Development and use of climate resilient crop varieties** with an aim to improve yields against adverse conditions. In a recent development, 109 climate resilient varieties of different field and horticulture crops were dedicated to the nation. However, taking these inventions from lab to land is extremely crucial.
- **Adjusting Cropping system with weather pattern through policy interventions:** Interventions that support climate resilient agriculture and promote sustainable farming practices should be implemented. For example, Uttarakhand has banned summer paddy cultivation in parts of Terai region to conserve ground water and promote maize farming as a sustainable alternative. Maize requires only a fifth of the water consumed by paddy.

- **Establishing Public-Private Partnerships:** Framework for carbon credit trading schemes that promote adoption of eco-friendly agricultural practices by small and marginal farmers and incentivize farmers should be developed/ strengthened. Agri-finance partnerships with private sector to provide tailored products that motivate farmers to adopt advanced and good agricultural practices should be implemented.
- **Farmer Community Involvement for sustainable agriculture:** Involving progressive farmers and anchor FPOs who adopt modern and sustainable agricultural practices to mentor and guide other farmers helps in spreading awareness, quicker adoption and bring collective strength. In Andhra Pradesh, progressive farmers following Zero-Budget Natural Farming (ZBNF) using natural agri inputs and no chemical fertilizers or fertilizers have trained farmers in their community, leading to its extensive success. Likewise, a FPO based in Pune, Maharashtra aggregated grapes farmers from 16 Grape Grower Cooperative Societies and has trained them in sustainable farming practices, quality control, and market access.
- **Reduction of food loss and waste**: To improve sustainability, it is crucial to reduce food losses and waste happening in each step in the farm to table. This can reduce the pressure on natural (land and water) resources, efforts spent by farmers and producers, landfills from waste, GHG emissions and further reduce the impact on climate change. Continued efforts to improve the investments in the food storage, warehouse, cold chain and transportation infrastructure and ensuring the availability of the infrastructure closer to the production and farms will help reduce post-harvest losses. In addition, anaerobic digestion of food wastes, manure and farm by-products can be promoted to produce biogas. Setting up of biogas plants is already a part of Galvanizing Organic Bio-Agro Resources Dhan (GOBARdhan) initiative and can be further emphasized for food processing units, dairy units, farmer groups and communities.

Given the challenges associated with mitigation which involves historical emissions, differing national interests and priorities, significant investment in new technologies & infrastructure, stage of Industrial Revolution (4.0) that the world is at, currently, adaptation is likely to play a critical role in addressing climate change, particularly in the short term. However, both mitigation and adaptation are necessary and complementary approaches to effectively address the complex & multifaceted nature of climate change.

SOIL, SUSTAINABILITY, AND SCALE: A TECH-DRIVEN PATH TO CLIMATE RESILIENCE FOR INDIA'S FARMERS

In 2016, while visiting a village in South India, I witnessed a funeral of a farmer who had taken his own life after his crops failed due to a lack of rainfall. The weight of that moment has never left me. It underscored the stark vulnerability of those who grow our food, and it exposed the devastating intersection of climate change, soil health, and farmer livelihoods. At the time, I was studying materials science, computer science, and AI at Caltech. I began to ask myself: could the tools of technology help prevent such tragedies? Could we build something that supports those who are most impacted by climate shifts, yet are the least responsible for them?

That moment led me to found Boomitra—an AgTech innovator and carbon project developer, now operating in over 10 countries globally, working to empower farmers, restore degraded lands, and deliver measurable climate impact.

Erratic rainfall, rising temperatures, and declining soil fertility are placing enormous strain on farmers—especially women and indigenous growers, who often lack equal access to resources, support, and technology.

The Hidden Power Beneath Our Feet

India's agricultural backbone is its smallholder farmers, many of whom work land that has been passed down through generations. But this tradition is now colliding with a rapidly changing climate. Erratic rainfall, rising temperatures, and declining soil fertility are placing enormous strain on farmers—especially women and indigenous growers, who often lack equal access to resources, support, and technology.

Farming is a hard business. Shifting the way you manage your land, crops, and herds can be risky. For many, the cost of adopting new practices feels like a gamble they can't afford. At Boomitra, we work to remove that risk. We and our local partners provide support, education, and technology to help farmers adopt regenerative practices that improve their soil and their livelihoods.

This matters not only for India but for the world. Farmers in the Global South manage 70–80% of the world's farmland, yet they receive less than 0.03% of global carbon finance. If we're serious about climate action, that must change. And soil—often overlooked—is one of our most powerful, and immediate, climate tools.

Building a Model for India's Future

In India, Boomitra operates two major soil carbon projects. The first spans over 70,000 hectares and involves more than 73,000 smallholder farmers. The second covers over 20,000 hectares and supports 12,000 farmers. Across both, we promote regenerative practices such as no-till farming, mulching, organic soil amendments, and water management.

About the **AUTHOR**

Aadith Moorthy is the founder and CEO of Boomitra. He is a Stanford Knight-Hennessy Scholar and Earthshot Prize winner, recognized globally for pioneering scalable, tech-enabled climate solutions for farmers. He was also named to the TIME100 Next list, recognizing emerging global leaders shaping the future.

But we don't work alone. One of the keys to our success is partnering with Farmer Producer Organizations (FPOs), women's groups, local governments, and NGOs that already have deep roots in these communities. These partnerships help build trust, tailor education to local needs, and make adoption of new practices feasible—even for the most marginalized farmers.

Participation in our projects is always free. Once farmers adopt regenerative practices, Boomitra uses remote sensing and AI-powered technology to measure improvements in soil carbon. This generates verified carbon credits, which are then sold to corporations and governments seeking to meet their sustainability targets. The majority of the revenue from those credits goes back to the farmers, creating a new income stream that reinforces climate-smart agriculture.

Already, we're seeing early results: improved yields, reduced input costs, and stronger financial resilience among participating farmers.

Take Vertika Chowdhary, who farms with her extended family in Uttarakhand. Initially skeptical of moving away from pesticides and synthetic fertilizers, she joined Boomitra's program in 2020. Today, she composts household waste and cow dung to create natural fertilizer, has stopped burning crop residue, and reports harvesting over 15 quintals more sugarcane than previous seasons. "Now that our fields are in a natural balance," she says, "we don't need to pay for pesticides." Vertika and other women in her village have formed a farmer group that shares knowledge and supports one another during harvests.

Shivling Chowgla, a farmer from Karnataka, tells a similar story. Once plagued by hard, unyielding soil, his land now retains more water and supports better crop growth thanks to improved practices like intercropping and the use of Jeevamrutham, a natural biofertilizer. Shivling relies on Boomitra's app for real-time insights on soil and plant health—delivered in his local language—which helps him make informed decisions while reducing costs.

Soil carbon sequestration—if scaled equitably—can be one of the most immediate and affordable pathways to meaningful climate impact.

Technology That Works for Farmers

Boomitra's Measurement, Reporting, and Verification (MRV) system is the first Verra-approved methodology to use AI and satellite remote sensing to quantify soil carbon stocks. This innovation dramatically reduces the cost of monitoring while increasing transparency, accuracy, and scale.

It also helps farmers. Through the free Boomitra app, farmers can access data-driven insights on soil health, moisture levels, nutrient availability, and more. These tools allow them to make informed decisions that increase productivity and reduce unnecessary costs. The app is available in regional languages like Hindi, Telugu, and Kannada, and we provide video training to ensure it is accessible to all.

By combining cutting-edge technology with local relevance, we ensure that even farmers with just an acre of land can participate in and benefit from the carbon economy.

Toward Gigaton-Scale Solutions

The urgency of the climate crisis demands gigaton-scale solutions. Soil carbon sequestration—if scaled equitably—can be one of the most immediate and affordable pathways to meaningful climate impact. But to unlock its full potential, we must include the farmers who steward the land.

India, with its deep agricultural heritage and rising innovation ecosystem, has a unique opportunity to lead. By combining ancient wisdom with modern science, we can regenerate our soils, uplift rural communities, and contribute significantly to global carbon removal.

The Road Ahead

At Boomitra, we're proud to have been recognized with The Earthshot Prize and named to TIME's list of 100 Most Influential Companies. But our real pride comes from what's happening on the ground: restored soil, stronger harvests, and renewed hope.

The path to climate resilience runs through our fields. It begins with the soil beneath our feet, the farmers who care for it, and the technology that can help us all go further, together.

CLIMATE-PROOFING THE RICE SECTOR

Water-saving technologies such as Alternate Wetting and Drying (AWD) have shown to reduce water usage by up to 30 percent and cut methane emissions by nearly 48 percent.

Climate change presents a profound challenge to global food security, particularly for rice production, a staple for over 50 percent of the world's population. Rising temperatures, unpredictable rainfall patterns, increasing salinity, and extreme weather events are testing the resilience and productivity of rice farming systems. In the face of these challenges, we are called to ask a crucial question: how can we secure rice production amidst a changing climate while safeguarding the communities that cultivate it?

In response, the International Rice Research Institute (IRRI) is passionately driving adaptation and mitigation strategies to ensure the sustainability and resilience of rice cultivation for future generations.

Breeding Climate Smart Rice

A cornerstone of these initiatives is the development of stress-tolerant rice varieties, which form the basis for enhancing resilience to climate variability. Through advanced breeding and genetic research with tools including genomic selection, gene editing, speed breeding, and artificial intelligence, IRRI is advancing a range of improved rice varieties that are specifically tailored to withstand temperature extremes and other environmental stresses of specific agroecological zones. Heat-tolerant varieties such as DRR Dhan 47 and DRR Dhan 52 have been developed to maintain stable yields in high-temperature environments. To address the growing issue of water scarcity, drought-tolerant varieties like Sahbhagi Dhan, DRR Dhan 42, DRR Dhan 44, and Swarna Shreya have been released to support farmers in rainfed regions.

In areas frequently affected by flooding, IRRI introduced submergence-tolerant varieties such as Bina Dhan 11, CR 1009 Sub 1, Swarna-Sub1, Samba-Sub1, and IR64-Sub1. These varieties can survive underwater for up to two weeks and are well-suited for flood-prone ecosystems in eastern and southern India. For regions facing both drought and submergence, multi-stress

About the **AUTHOR**

Ankita Tiwari is Specialist - Communication in International Rice Research Institute. The International Rice Research Institute is a member of the CGIAR System Organization, a global research partnership for a food secure future.

tolerant varieties such as Swarna Samriddhi, DRR Dhan 50, CR Dhan 801, and CR Dhan 802 offer valuable resilience. In coastal areas with saline soils, varieties like CSR 36 and CSR 43 provide sustainable cultivation options, helping farmers maintain productivity in challenging conditions. Along with several hybrid rice and Green Super Rice (GSR) varieties offering high yields under diverse environmental conditions have been developed in collaboration with national and international partners. Naming a few are PR 126, BRRI Dhan 69, Bina Dhan 17, and DRR Dhan 56, delivering improved productivity and stress tolerance.

Building Climate Resilience Through Smart Agronomy

In addition to genetic improvement, smart agronomic approaches can be integrated to strengthen the resilience and optimize production and productivity.

Water-saving technologies such as Alternate Wetting and Drying (AWD) have shown to reduce water usage by up to 30 percent and cut methane emissions by nearly 48 percent. The adoption of Direct Seeded Rice (DSR) further helps conserve water and lower labor costs. Site-Specific Nutrient Management (SSNM) techniques are being promoted to optimize fertilizer use, improve nutrient efficiency, and reduce greenhouse gas emissions. Innovations like the repurposing of rice straw for bioenergy and organic soil enrichment, rather than open burning, contribute to climate mitigation.

Subsequently, to ensure these innovations reach farmers on the ground, strengthening seed systems in partnership with National Agricultural Research and Extension Systems (NARES) is equally important. These collaborations aim to improve the availability and accessibility of high-quality, climate-resilient seeds. Efforts to enhance seed delivery mechanisms, combined with targeted policy interventions, are helping scale up the adoption of climate-smart rice varieties across South Asia and beyond.

Capacity development is an equally important investment as resilient farming can't be achieved through just tools, it involves behavioral changes and informed approach.

Vulnerable to Resilient: A Case Study

A powerful example of successful scaling comes from Assam. The South Asia Regional Centre of IRRI (ISARC, situated in Varanasi) worked with the Government of Assam and Assam Agricultural University under the World Bank-funded APART (Assam Agribusiness and Rural Transformation) project. The introduction of flood and stress-tolerant rice varieties with suited innovative agronomic practices gradually resulted in large scale adoption of the varieties.

Jorgaon village located in Morigaon district of central Assam is a flood-prone region where rice cultivation was adversely affected routinely. This raised a demand of climate-resilient technology amongst the local farmers to protect their crops from the fury of the monsoon. Under the APART project, ISARC introduced and actively distributed stress-tolerant rice variety seeds, covering approximately 4.5 lakh hectares across Assam between 2018 to 2023. The varieties introduced—such as Swarna-Sub1, Ranjit-Sub1, Bina Dhan 11, and Bahadur-Sub1— demonstrated strong performance even under adverse climatic conditions. Encouraged by this outcome, the entire village consisting of 125 households, began cultivating the flood-tolerant Sub1 varieties, particularly the Ranjit-Sub1. **Rabin Bordoloi**, a farmer from Jorgaon says, "In our village, every farmer now grows the Ranjit-Sub1 variety on at least one bigha of land. With the support of APART project, many of us were introduced to these flood-tolerant seeds. For those who couldn't access the initial distributions, we've built a strong system of sharing seedlings among ourselves. This way, more and more farmers are gradually shifting from traditional varieties to resilient ones like Ranjit-Sub1. Our aim is to gradually replace all traditional strains with the submergence-tolerant Ranjit-Sub1 variety."

This initiative has not only improved productivity and reduced climate-related risks for smallholder farmers but has also strengthened the local seed system and fostered long-term resilience in one of India's most climate-vulnerable regions.

Tackling Climate Risks through Capacity Development

Capacity development is an equally important investment as resilient farming can't be achieved through just tools, it involves behavioral changes and informed approach. Through training programs, field demonstrations, and collaborative learning, IRRI is equipping farmers with the knowledge and skills needed to adapt to and mitigate the impacts of climate change. These efforts extend to extension personnel and policy stakeholders, ensuring a supportive environment for climate-smart practices to thrive. The focus on building local expertise and farmer empowerment ensures that innovations are not only adopted but also sustained over time.

Addressing climate change requires more than isolated solutions- we need multifaceted yet integrated methods. When we are talking about climate resilience in agriculture, scientific innovations, policies and advocacies, and on-the-ground impacts needs to fit like pieces of a well-designed puzzle. As climate challenges intensify, so must our efforts. We need more partnerships, greater investment, and faster scaling of climate-smart innovations that work. Now is the time to act—to support, to scale, and to sustain the momentum that millions of livelihoods in the agri-food based systems depend on.

INDIA'S FIELDS OF THE FUTURE PLANTS UNDER SOLAR PLANTS

The afternoon sun blazes over Najafgarh, a village on the outskirts of Delhi near the Delhi-Haryana border, as 52-year-old farmer Mr. Dagar wipes the sweat off his brow while inspecting his thriving tomato crop. Unlike his neighbours, who anxiously scan the sky for rain clouds and worry about depleting groundwater, Mr. Dagar walks with quiet confidence through neat rows of green vines heavy with ripening fruit. Above him, sleek solar panels glisten under the relentless sun, casting a dappled shade over his fields. These are not just any solar panels - they are the lifeline of a new farming future, an agrivoltaics pilot project that allows him to harvest both energy and food from the same plot of land.

Agrivoltaics, or agro-photovoltaics, integrates solar power generation with agriculture by allowing food production and energy generation on the same piece of land.

For years, farmers in this region have faced a relentless battle against climate change - unpredictable monsoons, scorching heatwaves, and declining water tables have turned traditional farming into an uncertain gamble. But agrivoltaics has changed everything for Mr. Dagar. The panels shield his crops from the harsh sun, reducing soil evaporation and protecting delicate plants from ex-

About the **AUTHORS**

Shubhashree Chakraborty is the Manager ofIndia Agrivoltaics Alliance and Subrahmanyam Pulipaka is the CEO of National Solar Energy Federation of India

treme temperatures. Beneath the panels, the microclimate is cooler, requiring less irrigation. The energy generated on his land has opened additional income streams to his family.

Agrivoltaics - A Sustainable Way to Increase Yields and Energy Access

Behind this quiet transformation is **Sunmaster**, a renewable energy firm that took a bold leap by investing in agrivoltaics on underutilized land at Delhi's edge. Recognizing the low agricultural productivity of the region, Sunmaster installed elevated solar modules tailored for dual land use, pooling in capital for mounting structures, inverters, and evacuation infrastructure. To mitigate risk, they followed a phased approach: starting small, monitoring crop performance seasonally, and scaling gradually. Convincing Mr. Dagar and his family wasn't easy - as they were unfamiliar with solar technology and unsure how crops would fare under partial shade. But with trust-building and early results, doubt gave way to hope.

This dual land-use model is not just a scientific experiment; it is a quiet revolution with the potential to revolutionize India's agrarian landscape. Across the country, quite a few of such agrivoltaic pilot installations are emerging as a beacon of hope for small and marginal farmers, offering a sustainable way to increase yields and energy access while reducing dependence on erratic weather patterns.

Agrivoltaics across the Country

In Maharashtra, grape growers are using elevated solar panels to shield their delicate vines, ensuring better fruit quality and consistent yields. In Madhya Pradesh's Bundelkhand landscapes, solar arrays provide much-needed shade for horticulture and fodder crops, boosting agricultural resilience in water-scarce regions.

This farm now incorporates organic farming practices, and supplies fresh, organic produce to a nearby private hospital, where it is used to prepare meals for patients. Crops like brinjals, bananas, pomegranates, cabbage, turmeric, broccoli, and chillies are grown with care, meeting the demand for healthy, farm-to-table food. This organic shift has improved the nutritional value of his crops, benefiting both the hospital's patients and the local community.

In a country like India, where 47% of land is under agriculture and energy demand is surging, agrivoltaics offers a unique synergy between food security and clean energy generation.

In a similar case in Bundelkhand, Madhya Pradesh, Khare Energy has pioneered agrivoltaic projects, using its sites as living laboratories for experimenting with various crops. Alongside traditional crops like maize - which has shown no significant yield loss under the panels - Khare Energy is also testing strawberries, watermelons, leafy vegetables and medicinal plants, crops that thrive under the modified microclimatic conditions created by the solar panels. These projects demonstrate how agrivoltaics can improve crop resilience, especially in water-scarce regions.

In western India, the 1.5 MW Manwath agrivoltaics pilot in Parbhani, Maharashtra, set up by GIZ+SunSeed offers a strong example of farmer-centric innovation. The site includes four distinct agrivoltaic setups, with the flagship 3.75m shade-house generating over 10% bifacial gains (compared to 3–4% in conventional setups). It supports a variety of crops including flowers (Dutch Rose, Marigold, Tuberose), leafy greens, fruits (Muskmelon, Watermelon, Banana), and high-value produce like Betel leaf and Cherry tomatoes. Farmers receive hands-on training in shade-adapted cultivation, efficient irrigation, and market linkages. The project also facilitates comparative crop performance studies and is generating vital research like crop-specific photosynthesis response curves to inform future agrivoltaics design and strategies.

Why Agrivoltaics?

Agrivoltaics, or agro-photovoltaics, integrates solar power generation with agriculture by allowing food production and energy generation on the same piece of land. The practice encompasses multiple formats - such as elevated, vertical, or semi-integrated panels - and supports a wide range of agri-activities beyond crops like – animal husbandry, cattle grazing, bee keeping etc. This approach maximizes land use efficiency, enhances water retention, moderates microclimate, and provides additional

income for farmers.

In a country like India, where 47% of land is under agriculture and energy demand is surging, agrivoltaics offers a unique synergy between food security and clean energy generation. Globally, it has been shown to reduce water use by up to 30% and boost combined land productivity by as much as 70%. Agrivoltaics also supports India's Nationally Determined Goals (NDCs) under the Paris Agreement, including the target of 500 GW non-fossil fuel capacity by 2030 and a 45% reduction in emissions intensity. With agriculture accounting for 14% of India's greenhouse gas emissions, integrating solar into farming can help decarbonize the sector, improve irrigation efficiency, and contribute to key Sustainable Development Goals such as affordable energy, climate action, and zero hunger.

India Agrivoltaics Alliance

The India Agrivoltaics Alliance was formed in response to the growing need for a dedicated platform to drive agrivoltaics adoption in the country. Anchored by NSEFI and steered by 10 other like-minded organizations, the Alliance was launched in 2023 to unite stakeholders, including policymakers, researchers, industry leaders, and farmers, to create a collaborative ecosystem for agrivoltaic expansion. The Alliance advocates for policy inclusion, develops financial and business models, and promotes workforce participation, particularly among women and youth. By actively engaging with ministries such as MNRE, the Ministry of Agriculture and Farmers' Welfare, and the Ministry of Rural Development, IAA has positioned itself as a key advocate for agrivoltaics in India.

Since its inception, the India Agrivoltaics Alliance (IAA) has followed a two-pronged strategy: policy advocacy and on-ground stakeholder engagement. It has actively worked in Maharashtra and Uttar Pradesh, creating state-specific roadmaps, conducting capacity-building sessions, and releasing key resources such as the Policymakers' Handbook, Farmers' Handbook, and business model studies. Looking ahead, the Alliance aims to scale up nationwide, with a strategic focus on North-Eastern states. Its next phase involves establishing pilot projects across varied agro-climatic zones and landholding patterns, unlocking investments, promoting partnerships, and crafting a national roadmap to embed agrivoltaics within India's core agriculture and energy policies.

Policy Intervention

Several Indian states are leading the way in integrating agrivoltaics within their renewable energy and agricultural policies. Uttar Pradesh has become the first state to officially recognize agrivoltaics, recently declaring its public commitment to the technology. In order to make agrivoltaics mainstream in India, a combination of policy and non-policy measures is essential. Policymakers must develop clear regulatory frameworks, financial incentives, and technical guidelines to promote large-scale adoption. Expanding initiatives like the PM-KUSUM scheme, providing subsidies, and simplifying land-use policies can accelerate deployment. Additionally, dedicated research into crop-solar compatibility, region-specific agrivoltaics models, and financial viability will further bolster confidence among farmers and investors. On the non-policy front, awareness campaigns, farmer training programs, and collaboration with industry stakeholders can play a crucial role. Encouraging private sector participation through public-private partnerships (PPPs) and demonstrating the economic feasibility of agrivoltaics through successful pilots will help build trust and momentum.

For Indian farmers, agrivoltaics can be a game-changer. By diversifying their income streams, reducing irrigation needs, and increasing crop resilience, farmers can secure their livelihoods against climate uncertainties. The integration of solar power into agriculture can also lead to rural electrification, job creation, and technological advancements in the farming sector. As the sun continues to shine on India's vast farmlands, agrivoltaics offers an opportunity to harness its power twice - once for energy and once for food - ushering in a new era of prosperity and resilience for the nation's farmers and transforming every farm into not only a food basket but also a power hub for the nation.

CASE STUDY

GROUP MICRO-IRRIGATION

A PATHWAY TO CLIMATE-RESILIENT FARMING IN SEMI-ARID INDIA

When Water Becomes Scarce, Collective Action Becomes the Answer

Across India's vast agricultural landscape, water is the quiet force that determines a farmer's fate. Over 60% of irrigated farming in India depends on groundwater—an underground lifeline that also supplies more than 85% of the country's drinking water. But this critical resource is drying up, literally and figuratively. Over-extraction, climate-induced rainfall variability, and inequitable access to water have pushed rural communities into a vicious cycle of uncertainty and distress.

While drip and sprinkler systems—broadly termed micro-irrigation (MI)—have long been promoted as solutions, they often remain out of reach for the small and marginal farmers who need them most. The high cost of installation, fragmented land holdings, lack of technical know-how, and limited market access form real barriers.

The question, then, is: Can micro-irrigation be made accessible, affordable, and equitable—especially for vulnerable communities in semi-arid regions?

About the **AUTHOR**

Arun Bhagat is Senior Researcher, WOTR Centre for Resilience Studies (W-CReS), Watershed Organisation Trust (WOTR), Pune

The Watershed Organisation Trust (WOTR) believes the answer lies in working together.

A New Approach: Group Micro-Irrigation (GMI)

WOTR's Group Micro-Irrigation (GMI) model blends technology, community cooperation, and climate-aware agriculture into a single, scalable solution. At its core is a simple but radical idea: treat groundwater as a common resource to be shared, not divided. Through community-managed drip irrigation systems, smallholder farmers come together to use water more efficiently, equitably, and sustainably.

But this isn't just about irrigation. GMI is supported by four pillars that reinforce each other:

Groundwater Management

The process begins by reviving the natural base—groundwater. Through the construction of check dams, farm ponds, percolation tanks, and other soil and water conservation measures, the system ensures improved groundwater recharge. Instead of relying on individual

pumps, the farmers install a shared drip irrigation system sourced from a common well, bringing fairness and efficiency into how water is used.

Climate-Resilient Agriculture (CRA)

With water security comes the opportunity to improve how farmers grow their crops. WOTR trains farmers in a range of CRA practices—seed treatment, proper crop spacing, intercropping, use of organic inputs like vermicompost and Jeevamrut, and eco-friendly pest control through pheromone traps and neem-based biopesticides. These practices not only reduce dependency on chemical inputs but also protect the soil and ensure long-term productivity.

Market Linkages

The GMI model also connects farmers with Farmer Producer Organisations (FPOs) to improve bargaining power and ensure fair prices. For farmers used to being at the mercy of middlemen, this shift is transformative. It allows them to plan their cropping cycles with greater confidence and a clearer sense of market demand.

Applied Research and Monitoring

Participating farmers are not just recipients of knowledge—they become researchers in their own fields. With support from WOTR's applied research wing, W-CReS, they conduct crop water budgeting, discharge tests, and keep field records. This data-driven approach fosters learning, accountability, and better planning across seasons.

Tigalkheda: A Case Study in Jalna District

This integrated approach came to life in Tigalkheda village, located in the semi-arid zone of Jalna district, Maharashtra. In April-May 2018, a group of 14 farmers decided to take a leap of faith. Using water from a shared dug well, they installed a group drip irrigation system that covered 32.45 acres of land.

Let's examine the transformation they achieved in just two years.

Group Micro Irrigation (GMI) Tigalkheda, (Jalna, Maharashtra)

Pre-intervention year: 2017 | Post-intervention years: 2018 and 2019

No of Farmers	Year of establishment	Area (Acre)	Water Source
14 Farmers	April-May, 2018	32.45	Dug well

I. Increase in Cropped Area

By adopting drip irrigation and CRA practices, farmers expanded their total cropped area by 43.68%, with the Rabi season witnessing a 106% increase—a major boost considering the water-scarce conditions.

Cropping Season	Pre-intervention cropped area (Acre)	Post-intervention cropped area (Acre)	Change in cropped area (%)
Kharif	29.47	32.45	10.11
Rabi	15.7	32.45	106.69
Summer	0	0	0
Total	45.17	64.9	43.68

II. Rise in Cropping Intensity

Pre-intervention		Post-intervention		Rise in cropping intensity (%)
Annual cropped Area (Acre): 45.17	Cropping Intensity (%): 139.20	Annual cropped Area (Acre): 64.9	Cropping Intensity (%): 200	60.80

III. Irrigation Shift: From Partial to Full

Irrigation Status	Pre-intervention irrigated area (Acre)	Post-intervention irrigated area (Acre)	Change in irrigated area (%)
Kharif - Full	0	32.45	100
Rabi - Full	0	32.45	100
Summer - Full	0	0	0
Kharif - Partial	29.47	0	-100
Rabi - Partial	15.7	0	-100

IV. Crop Diversification and Area Expansion

With assured water, farmers shifted their cropping pattern to include more high-value crops and expand acreage.

Cropping Season	Pre-intervention	Area	Post-intervention	Area
Kharif	Maize	13.7	Maize	10.25
	Cotton	13.9	Cotton	6
	Soybean	2.5	Soybean	16.2
Rabi	Wheat	5.57	Wheat	18.2
	Chickpea	4.25	Chickpea	8
	Sorghum	5.25	Sorghum	6.25

V. Crop Productivity Soars

Better irrigation, timely sowing, and CRA practices helped boost productivity significantly.

Crop	Pre-intervention (Quintal/Acre)	Post-intervention (Quintal/Acre)	Rise in crop productivity (%)
Sorghum	2.96	4.68	58.11
Cotton	8.38	9.91	18.26
Soybean	6	9.1	51.67
Wheat	6.87	10.5	52.84
Chickpea	5.31	7.76	46.14
Maize	14.09	22.15	57.20

VI. Improved Water Use Efficiency

Perhaps most significantly, water productivity (measured as kg/ha-mm) rose sharply—proving that GMI delivers more yield for every drop.

Crop	Pre-intervention (kg/ha-mm)	Post-intervention (kg/ha-mm)	Rise in water productivity (%)
Sorghum	1.85	2.95	59.46
Cotton	2.67	3.16	18.35
Soybean	3.07	4.66	51.79
Wheat	3.12	4.77	52.88
Chickpea	4.43	6.47	46.05
Maize	5.87	9.23	57.24

Over 60% of irrigated farming in India depends on groundwater—an underground lifeline that also supplies more than 85% of the country's drinking water.

Looking Ahead: Scaling a Proven Model

The Tigalkheda story demonstrates the immense potential of group-based, climate-resilient irrigation systems in semi-arid regions. When supported by collective governance, agronomic best practices, and access to markets, Group Micro-Irrigation emerges as a powerful pathway to boost farmer incomes, conserve water, and build long-term resilience.

The way forward lies in scaling such models, backed by supportive policies, awareness programs, and access to credit and training. As climate uncertainty looms larger, GMI offers a glimmer of hope—showing that when communities work together, even the harshest conditions can be overcome.

Navigating Challenges and Solutions in India's Rice Supply Chain

India, the world's largest exporter of rice, is a cornerstone of global food security. Renowned for its diverse varieties, including the premium Basmati and non-Basmati rice, the country significantly contributes to both domestic consumption and international trade. Basmati rice, often referred to as the "God of Grains," undergoes extensive processes and certifications to ensure its highest quality and signature aroma. However, delivering top-quality rice to consumers depends heavily on an efficient supply chain.

The supply chain process begins with the cultivation and procurement of high-quality seeds. Seed quality affects the yield; hence manufacturers are invested in the same at the seed level. This involves engaging a network of farmers to provide them with superior seed varieties, advanced techniques, and necessary support. The next phase is processing and milling, which includes key sub-processes like dehusking, polishing, and grading. For Basmati rice, ageing is a critical component of the process. Following this, the rice undergoes stringent certifications and quality assurance checks. The final stages involve packaging and distribution. Supply chain efficiency is evaluated based on the integration of ERP systems for inventory management and real-time tracking, as well as effective collaboration with logistics partners to ensure timely delivery. Despite its critical role, this complex chain faces numerous challenges that must be addressed for sustained growth and excellence.

Emerging techniques, such as Alternate Wetting and Drying (AWD) and Aerobic Rice methods, can reduce water consumption by up to 30–45% and as low as 1,200–1,500 liters per kilogram, respectively.

About the **AUTHOR**

Ashish Mittal is the Head of Ghaziabad Plant, KRBL. KRBL Limited is an Indian rice processing and exporting company, and the world's largest rice miller. It is best known for its India Gate brand of basmati rice, which is the largest selling rice brand in India.

Challenges in Rice Farming

Basmati rice is a highly water-intensive crop, needing approximately 2,500 liters of water to produce one kilogram. The declining groundwater levels, particularly in Punjab and Haryana regions, pose a significant challenge to the sustainability of rice farming. Additionally, the crop relies heavily on monsoon rains, which are often inconsistent in India. Rising temperatures, erratic rainfall patterns, and increasing pest infestations further exacerbate the difficulties faced by Indian farmers. However, India is actively addressing these challenges through sustainable agricultural practices, including the development of drought-resistant rice varieties and improved water management techniques, to mitigate the impact of climate change on rice production.

The other major challenge is storage and infrastructure. Rising temperatures and humidity levels heighten the risk of fungal infestations and pest attacks during storage. Additionally, storage facilities with inadequate ventilation may have difficulty maintaining the optimal conditions required for ageing Basmati rice. India's expansive geography requires rice to be transported over long distances, from farms to mills, wholesalers, and retailers. However, inadequate road infrastructure, limited railway connectivity, and outdated logistics systems often lead to delays and increased costs. For rice companies, these inefficiencies result in higher operational expenses and lower profitability.

Other than this, global challenges also impact rice crops in India. Sudden export bans or restrictions imposed by the Indian government to stabilize domestic prices can disrupt international trade and lead to supply shortages. Additionally, trade tariffs imposed by other countries may impact the cost and volume of exports. For example, higher tariffs on rice exports from India to certain regions can make Basmati less competitive compared to local alternatives.

Sustainability and the Road Ahead

India is actively addressing the multifaceted challenges in the rice supply chain through sustainable agricultural practices, technology adoption, and infrastructure development. One major focus is improving the availability of high-quality seeds with higher yields and lower water consumption. Despite efforts from government agencies and private players, the lack of sufficient quality seeds has led to excessive water usage in paddy fields. Traditional flooded rice cultivation requires around 4,000 to 5,000 liters of water per kilogram of rice. Emerging techniques, such as Alternate Wetting and Drying (AWD) and Aerobic Rice methods, can reduce water consumption by up to 30–45% and as low as 1,200–1,500 liters per kilogram, respectively. However, limited awareness among farmers about these methods hinders their widespread adoption.

Harvesting efficiency is another area requiring attention. Mechanized harvesting, while improving productivity, often leads to grain losses of 5–10%. Advancements in mechanical harvesters are essential to minimize these losses and improve farmers' profitability. Procurement challenges further complicate the supply chain. In local mandis, quality control during rice paddy procurement relies heavily on buyers' subjective skills, as rapid testing methods are unavailable. Moreover, in many regions, suboptimal harvesting and storage conditions lead to contamination by pests, fungi, or impurities, degrading the quality of rice. Poor storage infrastructure, particularly in remote rural areas, exacerbates the problem, increasing the likelihood of rejection during procurement.

By embracing eco-friendly practices such as water-saving cultivation methods and organic farming, India can meet the growing demand for sustainable rice while addressing environmental concerns.

From factory to fork, rice processing and logistics face their own hurdles. Processing rice is an energy-intensive activity, often reliant on outdated machinery. Replacing these with energy-efficient equipment and processes can significantly reduce energy consumption. Government subsidies to promote the adoption of such technologies would contribute to sustainability and reduce the nation's energy demands. Warehousing and storage also remain critical issues. With current storage costs in government godowns ranging from 0.8% to 1.5% of production costs due to multiple handling requirements, there is an urgent need for cost-effective and efficient storage facilities. Rising temperatures and humidity levels during storage increase the risks of fungal infestations and pest attacks, especially for Basmati rice, which requires specific conditions for ageing.

Transportation inefficiencies further strain the supply chain. The rice transportation sector is dominated by local aggregators and mediators, leading to high seasonal price fluctuations—ranging from 10% to 30%. Poor road and railway infrastructure often results in delays and increased costs, reducing profitability for businesses.

Collaboration among governments, businesses, and international organizations is crucial to overcoming these challenges. Public-private partnerships can drive investments in sustainable farming practices, improved infrastructure, and fair-trade policies, benefiting both producers and consumers. By embracing eco-friendly practices such as water-saving cultivation methods and organic farming, India can meet the growing demand for sustainable rice while addressing environmental concerns.

Despite these challenges, opportunities for innovation and growth in India's rice supply chain remain robust. Companies like KRBL are already leveraging advanced technologies such as ERP systems for real-time tracking and blockchain for transparency, streamlining operations and ensuring premium quality. With continued investment in technology, energy efficiency, and infrastructure, India is well-positioned to maintain its leadership in the global rice market and build a resilient future.

THE MISSING LINK IN CLIMATE ACTION: STRENGTHENING THE SOCIAL PILLAR FOR AGRICULTURAL RESILIENCE

Climate change is no longer a future threat. For millions of farmers worldwide, it is already interfering with the way they grow food and earn a living. Agriculture, by its very nature, is deeply reliant on climate: from the monsoon cycle to groundwater availability, soil health, and the innumerable services provided by the ecosystem. Shifting rainfall patterns, rising global and regional temperatures and extreme weather events are making agriculture more difficult and unpredictable than ever in human history. Recent analyses show that global agricultural productivity is now about 20% lower than it would have been without climate change, bringing down decades of progress.

The farming systems' ability to adapt and respond to these challenges varies widely. While some farmers are switching to stress-tolerant crops or changing their cultivation practices (e.g., early sowing) to escape heat stress, many are being left behind. Smallholders and marginalized communities are more vulnerable as they often lack the resources and institutional support to adapt quickly and effectively. For example, heat stress has been shown to reduce incomes of female-headed households more than male-headed ones, aggravating already existing inequalities.

To combat these climate change issues in agriculture globally, there are two types of responses: mitigation to reduce greenhouse gas emissions, and adaptation to help farmers adjust to changing climatic conditions. To be effective, both approaches require a combination of technological and social interventions. Most research-and-development (R&D) efforts focus on technological solutions, such as improved crop varieties or new agronomic practices, while undermining the social or institutional systems that decide how, where, when, and by whom these innovations are adopted. In other words, social and institutional factors are considered secondary to technological solutions. It is high time we realise that unless the human and institutional dimensions are addressed, even the most promising technologies may fail to reach and benefit those who need them the most.

Vijesh V. Krishna is Principal Scientist / Lead Economist, Sustainable Agrifood Systems (SAS) Program of International Maize and Wheat Improvement Center (CIMMYT), Hyderabad

Ashiq Parambil-Peedika is s currently working as – Research Consultant at SAS Program, CIMMYT, Hyderabad and a Ph D scholar from Salim Ali Centre for Ornithology and Natural History (SACON), Coimbatore

Why does the social pillar matter?

Social and institutional interventions are central to how communities adjust to climate challenges – they influence awareness, perceptions, adoption decisions, and the success of mitigation and adaptation efforts. Community organizations, collective action groups, and equitable access to information and resources can be as critical as breeding and agronomic innovations. Institutional innovations, such as inclusive governance frameworks, group-based and participatory extension systems, targeted safety nets, or increased access to machinery services and input markets, can either prepare the way for the adoption of technologies or deliver impact by themselves.

A case from the field

Agricultural R&D agencies across India are developing and disseminating different measures to combat climate (and associated) challenges. However, the success of these efforts often depends on the robustness of local institutions. A case in Kerala stands as a typical example. What began as a woman's concern over adulterated food turned into a kitchen garden and later a food enterprise. This progress was possible only because local institutions provided the right support at the right time: training, funding, licensing assistance, and mar-

ket exposure. The following first-person account (female, 48, Palakkad District, Kerala) highlights how this journey unfolded, and why local institutional support is key to building resilient livelihoods.

*"I'm part of a small women's group in the village V [*name removed*] in Palakkad. A few years ago, we were concerned about the quality of food we were buying, especially adulterated spice powders. Five of us, all members of our local 'Kudumbashree' collective, decided to grow our own vegetables and spices. We didn't know how or where to start, but a resource person from our panchayat office, who was also our friend, stepped in. She helped us in getting a small grant and introduced us to training in food processing. These workshops gave us practical skills and the confidence to do more.*

With further help from officials at the block and district levels, we obtained financial support, food safety licenses, and assistance to sell our products. That's how we started a small food enterprise, providing clean, home-processed food items in local markets. We were also able to help other women collectives by purchasing raw materials and selling them after processing as value-added products. It wasn't easy. Simple tasks like opening a bank account took weeks. But without this network of institutional support, we wouldn't have moved forward. For women like us, it's not all about technology or training. It's about having the right people and systems that back us when it matters."

Social and institutional interventions are central to how communities adjust to climate challenges – they influence awareness, perceptions, adoption decisions, and the success of mitigation and adaptation efforts.

Building on Experience: India's institutional Innovations offer Global Lessons

India has proved that social and institutional innovations can be as important as technological solutions in tackling climate challenges in agriculture. Several grassroots initiatives in the country demonstrate how effective local institutions, when inclusive and responsive, can support climate adaptation, improve equity, and empower communities.

One example is *Participatory Irrigation Management* in canal command areas in Andhra Pradesh. Here, farmers were organized into Water User Associations under the Andhra Pradesh Water Management Project with the help of capacity-building programs at individual and organizational levels from the regional agricultural university and international partners. These associations took over the planning, operation, and maintenance of irrigation systems. Not only did this improve water use efficiency, but it also promoted a sense of ownership, minimized conflict, and ensured more equitable distribution, which are particularly important in drought-prone conditions.

Another example comes from Karnataka, where *women's collectives* working in a wasteland development project developed their own conflict resolution mechanisms. In Shimoga District, members of *Pragathi Bandhu* groups resolved disputes through regular group discussions, rotation of leadership, and peer accountability. Social cohesion like this is vital for climate resilience, as collective decisions regarding land use, cropping, and water conservation can directly impact how communities adapt to climate stress.

In addition to these two, India has several such promising emerging institutional models to impart resilience to agricultural systems:

- Participatory guarantee schemes for organic farming. These institutions facilitate farmer-led certification processes, based on trust and peer review and ensure both sustainability and market access.
- Market committees with farmer representation promote transparency in pricing and help resolve disputes in real-time.
- Community-run custom hiring centres that allow farmers to access machinery without owning it, enabling timely sowing and harvesting

under shifting climate windows.

- Village-level assemblies with decision-making powers over land, forest, and water governance help align local priorities with climate strategies.
- Farmer-managed seed banks conserve climate-resilient local varieties and strengthen seed security.

What these examples have in common is the active participation of local people in organizations facilitating bottom-up decision-making. They help spread the benefits of climate action more fairly and build trust among stakeholders. Most importantly, they acknowledge that resilience involves surviving shocks, reducing vulnerability, and increasing agency.

These cases further show that climate resilience is not only a technical problem but also a social and institutional one. India's experience offers practical insights for other countries: when communities are entrusted with decision-making power and provided with supportive structures, they are more likely to engage with and sustain climate-resilient practices. Strengthening the social pillar is not just desirable – it is an essential step towards sustainable change and resilient systems.

India's experience offers practical insights for other countries: when communities are entrusted with decision-making power and provided with supportive structures, they are more likely to engage with and sustain climate-resilient practices.

Rethinking Innovation: Beyond Technology

It's time to broaden our definition of innovation in the context of climate-resilient agriculture. Not all innovations need to be technological. Many effective practices, such as collective seed banks, women's groups, and farmer-led market systems, are institutional or behavioural in nature. These social innovations often support or facilitate technological change, yet they receive far less attention and R&D investment.

One major obstacle is the lack of rigorous impact assessment on the social interventions. Without evidence on what works and why, it is challenging for the most vulnerable communities to adopt them, posing a significant challenge for inclusive scaling out. Moreover, many interventions have yet to fully incorporate behavioural insights, socio-technical dynamics, and the potential of digital tools to strengthen resilience and accelerate transitions.

Tackling climate change requires more than sectoral or discipline-based solutions. It demands interdisciplinary collaboration, inclusive research teams, and approaches that integrate science with lived experiences. Climate education, public participation, and mechanisms that enable the most vulnerable to shape solutions are as important as any technology. India, with its diversity of people, ecosystems, and institutions, has the potential to lead by example. It can show the world how investing in the social pillar is not just complementary, but essential to achieving real, lasting climate resilience. Investing in the social pillar, we can ensure that promising technologies can reach their full potential and help build lasting climate resilience.

PEPSICO INDIA'S AGRI INITIATIVES

PepsiCo India's agricultural initiatives focus on advancing regenerative farming practices, empowering farming communities in the supply chain. PepsiCo in India has been the pioneer in collaborative potato farming, and today works directly and indirectly, with 27,000 farmers across 14 states. They have established deep-rooted relationships with local farmers to encourage environmentally sustainable cultivation.

Under its collaborative farming program, PepsiCo India provides 360° support to farmers for potato cultivation – high quality seeds, assured buy-back of produce, bank loans and technology best practices in collaboration with agri-input companies.

The Commitment

Pep+ represents their outlook on business and the world around us. With a focus on driving end-to-end strategic transformation and sustainability, they aim to promote better agricultural practices, improve processes in the value chain, and provide the consumers with a wide range of healthy choices.

Agriculture is central to both global challenges and solutions and positive Agriculture includes their efforts to promote regenerative agricultural practices, increase water-use efficiency in crop irrigation, and sustainably source key ingredients from the suppliers. Farmers power their business – 100% of the potatoes used for their chips are being sourced from Indian farmers.

Project Mitti Didi:

Soil testing is often not a widespread practice; inaccurate reports and delays in receiving results are some of the biggest hurdles faced by farmers when testing soil. Seasonal farming practices also limit soil testing opportunities. To address these issues, they have enabled and trained women in Hathras district to operate a portable InSoil machine for soil health testing, empowering them to turn into agripreneurs. This machine tests soil across 12 key parameters, including Potassium, Magnesium, Boron, pH, and more, providing a comprehensive report within just 30 minutes. The report highlights any deviations from the ideal soil levels, offering farmers timely and accurate insights into their soil health. With timely information about their soil health, farmers are empowered to make informed decisions, leading to better planning and improved yields. The women operating this 'Mitti Didi' machine are now considered agripreneurs in their communities, enabling farmers in nearby communities with timely soil health testing reports.

Lay's Smart Farm

PepsiCo India partnered with Cropin for its award-winning initiative **Lay's Smart Farm**, to empower farmers with real-time insights for better crop management, yield forecasts, and disease warnings. These insights are made accessible through a user-friendly smartphone app. The heart of Lay's Smart Farm is an AI driven predictive intelligence model that combines satellite imagery with historical data. So far, Lay's Smart Farm has already demonstrated several benefits for farmers including accurate yield forecasting up to 45 days in advance, disease early warning alerts 10-14 days before occurrence and increased yield and reduced input costs for farmers. So far, 15000+ acres have been mapped through satellite imagery across 20000 plots, enabling 7000+ farmers.

Next Generation Agriculture in India

PepsiCo India's positive agriculture strategy focuses on regenerative farming practices, empowering farming communities in the agricultural supply chain. It has established deep-rooted relationships with local farmers to encourage environmentally sustainable cultivation.

THE CYCLE OF DEBT: HOW CLIMATE CHANGE IS DRIVING FARMERS DEEPER INTO FINANCIAL CRISIS

In the not-so-distant past, the dependence on rains for crops was not just common- it was natural. The recent years have seen an unprecedented drop in rainfed crop production which is concerning. By 2080, yields of staple crops like wheat and rice could decrease by 40% and 47%, respectively, threatening the livelihood of millions of Indians who rely on agriculture. These days, farmers deal with a disastrous combination of issues, including erratic weather patterns, rapidly rising expenses, and an acute shortage of financial assistance, which forces them into enormous amounts of debt.

By 2080, yields of staple crops like wheat and rice could decrease by 40% and 47%, respectively, threatening the livelihood of millions of Indians who rely on agriculture.

Never Ending Cycle of Debt

Due to chronic droughts, sudden flooding, and changing planting seasons, rain patterns have become severely unpredictable, making it difficult for farmers to adjust. As yields decline and entire harvests fail, those who depend on rainfall look on hopelessly. Many farmers have to take up loans in order to maintain their farms and provide for their families. Every year, the cost of seeds, fertilizer, and insecticides rises. Desperate farmers turn to local moneylenders, who demand outrageous interest rates and keep them in a never-ending cycle of borrowing, when banks reject them.

In India, the average debt of a farming household was ☐74,121 by 2019. This presents a serious threat to small farmers. Additional loans are frequently given at the expense of their land after repeated crop failures. They are forced to make the difficult choices regarding

About the **AUTHOR**

Dr. Eilia Jafar is a disaster management, environment and humanitarian professional with over two decades of experience, who has made significant contributions in areas like climate change adaptation, gender inclusion, and disaster risk reduction in different national and international humanitarian aid and service organizations.

selling their ancestral land, moving to a city, or, in the worst situations, taking their own lives when debt accumulates and repayment becomes unaffordable.

Many farmers remain vulnerable despite government programs like the Pradhan Mantri Fasal Bima Yojana, which attempted to offer crop insurance but included complex paperwork and limited outreach. Although the Kisan Credit Card program gave low-cost credit, many people cannot manage to afford it due to strict eligibility standards and lengthy processing times. At the same time, these safety nets are being swamped by the rising frequency of climate calamities. Farmers are left open to the next crisis because, when compensation does come, it rarely covers genuine losses.

Breaking the Cycle

Financial pressures extend beyond loans. Labour costs, electricity bills, and transportation expenses continue to rise, eating away at already thin profit margins. Without proper storage facilities, small farmers must sell immediately after harvest when prices hit rock bottom. Predatory middlemen dominate agricultural markets, ensuring farmers receive pennies on the dollar for their produce.

Breaking this devastating cycle requires urgent action. A combination of financial support, climate resilience measures, and institutional credit access is essential.

- **Leverage MGNREGA for climate resilience.** The program includes 164 agricultural projects focused on natural resource management. Rainwater harvesting, micro-catchment development, and soil conservation efforts can boost productivity while providing off-season employment, reducing dependency on loans. These initiatives also help regenerate damaged land and improve soil health.
- **Expand drip irrigation through PMKSY.** Water conservation benefits are enormous—farmers use water more efficiently, see better yields, and spend less on inputs. Investing in rural water storage would further buffer against erratic rainfall.

Due to chronic droughts, sudden flooding, and changing planting seasons, rain patterns have become severely unpredictable, making it difficult for farmers to adjust

- **Increase access to Kisan Credit Cards.** Small farmers desperately need institutional credit to escape predatory moneylenders. Simplifying applications and expanding coverage would make affordable loans accessible. Fair, transparent loan recovery practices must prevent further harassment of struggling farmers.
- **Deliver input subsidies directly to farmers.** Digital bank transfers for fertilizers, seeds, and pesticides would bypass middlemen. Encouraging organic farming methods would reduce reliance on expensive chemicals while improving long-term soil health.
- **Support women farmers.** Despite forming a large part of the agricultural workforce, women lack land ownership, credit access, and training opportunities. Targeted education and financial support would strengthen entire rural communities. Cooperative models and self-help groups could improve women's access to markets.
- **Implement targeted debt relief.** Loan forgiveness provides immediate relief for farmers in crisis. While not solving underlying problems, restructuring repayment periods and reducing interest rates would prevent further financial ruin.
- **Improve market access.** Strong farmer-producer organizations help small farmers negotiate fair prices. Better storage facilities, cold chains, and direct market channels would reduce waste and boost earnings. Digital marketplaces connecting farmers directly with buyers could eliminate exploitative middlemen.
- **Promote crop diversity and climate-resilient farming.** Dependence on a single crop leaves farmers vulnerable to disaster. Government extension services should promote drought-resistant varieties and agroforestry models that ensure long-term sustainability.
- **Build rural financial literacy.** Many farmers remain unaware of existing government schemes that could help them. Local programs teaching fundamental financial knowledge would help farmers make smarter decisions about loans, insurance, and savings.
- **Encourage community risk-sharing.** Cooperatives and self-help groups allow farmers to pool resources and distribute risk. This improves access to credit, enables bulk purchasing at lower prices, and strengthens negotiating power with buyers.

Climate change already threatens millions of farming families. Without immediate action, the debt spiral will only worsen, devastating rural communities. Securing farmer livelihoods and ensuring food security requires a comprehensive approach—financial support, infrastructure development, and policy reform. The time to act is now, before more farmers lose their land, their hope, and their lives.

MEETING OF TRADITION WITH TRANSFORMATION

"The intersection of climate change, sustainable agriculture, and profitability is at the heart of the agritech movement. Startups need to integrate sustainability into their core business models, ensuring that profit does not come at the expense of the environment. The future of agritech lies in creating businesses that balance profitability with social and environmental responsibility," says **Vineet Rai, Founder and Vice-Chairman, Aavishkaar Group**. In an exclusive interaction with Agriculture Today, Mr Rai discusses the role of agritech and how Aavishkar Group is looking at agri space.

As the Chair of the Agritech Pavilion, what can we expect from this edition of Startup Mahakumbh?

At Startup Mahakumbh, the Agritech Pavilion represents the meeting of tradition with transformation. This is the area where the wisdom of the farmers meets the youthful exuberance of startup entrepreneurs and their technology prowess to build a narrative where Indian farmers would deliver on the promise of Global Food security and enhance their own livelihood and contribution to the National GDP from Agriculture. This is the narrative of Viksit Bharat@2047 so beautifully espoused by our Prime Minister Shri Narendra Modi.

This year, the Agritech Pavilion is the largest pavilion at Mahakumbh and is twice as large as last year, with more than 100+ startups showcasing. The startups are showcasing advanced technology, innovative strategies, global thinking from Production thought processes, supply chain inefficiencies, resource mismanagement, and technology advancements. This edition promises to spotlight solutions that blend scalability with sustainability, embarking on a new era where technology catalyzes social and environmental impact. You would see new-age technology, IoT devices, new-age drones, cutting-edge biotechnology solutions, and at the same time, farmers' participation and enthusiasm around on-ground progress at the pavilion.

At the Agritech Pavillion, farmers would rub shoulders with startup founders, Scientists, angel investors, Venture funds, Investment bankers, and farmer-producer companies to discuss a farmer-centered world market. For us, Startup Mahakumbh 2025 represents a movement that's building a community, sparking collaboration, and inspiring startups to reimagine the future of Indian agriculture.

How do you see this platform shaping the future of agritech startups in India?

India's agritech ecosystem is at a crucial inflection point. Startup Mahakumbh is not just a showcase—it's a catalyst for systemic change. By bringing together farmers through Farmer Producer Companies with entrepreneurs, investors, government stakeholders, and corporates, this platform creates an environment where collaboration surpasses competition.

The intersection of climate change, sustainable agriculture, and profitability is at the heart of the agritech movement.

We see this pavilion being led by Farmers who are entrepreneurs working closely with global startups from agritech powerhouse countries such as Israel, the Netherlands, and the USA to integrate our farmers' wisdom in the solution to the Global Food Security challenge while also addressing global sustainability issues. We would like the Agritech Pavillion to represent the Indian tradition of sustainable growth with a global outlook.

We are very confident that this showcase of startup and farmer wisdom would enhance global flows of capital into the Agritech domain, along with mentorship and stronger global market linkages. This would inspire startups to build from India and for the world, doing so with the Indian farmer at the center, delivering inclusive growth a reality.

What are the current trends in agritech investments, and what key factors do investors look for in agritech startups today?

Indian Agriculture represents one of the largest potential addressable markets but is plagued with inefficiencies around input supply, productivity, post-harvest storage and high-quality processing and finance as the key challenges. It is obvious that technology would play a critical role in alleviating these challenges and it is also obvious that the farmer would at the centre of these technological innovations. A lot of work is happening around supply chain optimization, precision agriculture, weather technology, processing technologies, biotechnology, and sustainable food systems, including soil carbon credits and areas such as animal husbandry, poultry and alternate protein

Indian investors are looking at agritech as potential global companies that would not only build scale but also bring about new innovations in business models that would integrate smallholder farmers in the global supply chain as equal participants with strong economics for them.

How do you see emerging technologies like AI, IoT, and blockchain transforming smallholder farming in India? What challenges need to be addressed for wider adoption?

Emerging technologies like the ones mentioned are being used to predict weather patterns, optimize irrigation, and provide real-time data on soil health. This creates a connected ecosystem where sensors monitor crop conditions and alert farmers about pests or diseases. Blockchain can ensure transparency and traceability in the supply chain, helping farmers get a fair price for their produce.

We believe improved connectivity, better business models for affordability and improved margins and more work on awareness would help wider spread of these technologies backed by large long term investments. We see long term patient capital through Impact investment, a deeper Indian capital pool with strong government backing from Institutions such as NABARD and State Bank of India alongside aggressive venture capital and private equity has the potential to take these cutting-edge technological ideas deeper into India.

What policy changes or government initiatives do you believe could further accelerate agritech innovation and investment in India?

The Indian government has already made significant strides in supporting the agritech ecosystem, from initiatives

like PM-KISAN to the National Mission on Agricultural Extension & Technology. Moreover, thanks to strategic initiatives by the government and institutions like NABARD through its AgriSURE Fund, established with a corpus of Rs. 750 crore, exemplifies this commitment by supporting innovative, technology-driven startups in agriculture and allied areas.

Complementing this, the government's Agriculture Accelerator Fund has been instrumental in nurturing agri-entrepreneurs, providing financial assistance at both the idea and seed stages, thereby fostering innovation across various agricultural domains. These initiatives, among others, underscore a well-coordinated effort to foster innovation and sustainability in Indian agriculture, creating a conducive environment for agritech startups to thrive and contribute significantly to the sector's evolution.

With growing concerns about climate change and sustainable agriculture, how can agritech startups drive responsible farming practices while ensuring profitability?

The intersection of climate change, sustainable agriculture, and profitability is at the heart of the agritech movement. Startups need to integrate sustainability into their core business models, ensuring that profit does not come at the expense of the environment. The future of agritech lies in creating businesses that balance profitability with social and environmental responsibility. Responsible farming practices are not only viable but necessary for long-term business growth. We see emerging work around Soil Carbon green credits, Small Holder Farmer biosequestration projects integrating major impact goals into global business models helping us to alleviate farmer concerns, climate concerns and building long term business models.

What is your vision for the Indian agritech sector over the next five years? How do you see Aavishkaar Group contributing to this evolution?

I envision a scenario where technology is embedded at every level of farming, from the input stage and precision tools for farmers to AI-driven analytics for large-scale operations. I see Indian agriculture as one of the potential solutions for global food security concerns. We genuinely see multiple Indian agritech startups becoming unicorns and tapping the IPO markets over the next 5 years.

Indian investors are looking at agritech as potential global companies that would not only build scale but also bring about new innovations in business models that would integrate smallholder farmers in the global supply chain as equal participants with strong economics for them.

Aavishkaar Group will continue to play a catalytic role in this transformation. We will remain committed to investing in impact-driven agritech startups that are tackling the most pressing challenges in agriculture—be it through data science, renewable energy solutions, or innovative farming techniques. Our focus will always be on nurturing entrepreneurs with the larger vision of transforming agriculture for the greater good. In the coming years, we will work closely with farmers, innovators, policymakers, and global thought leaders to ensure that India is at the forefront of the agritech revolution. Our role will be to provide capital, mentorship, and market access, enabling local and global ecosystems so that these businesses can scale and deliver the lasting impact that India needs.

Organiser

भारतीय कृषि एवं खाद्य परिषद्
INDIAN CHAMBER OF FOOD AND AGRICULTURE

Co-organiser

NEBIF
NORTH EAST BUSINESS AND INVESTMENT FORUM

VIBRANT NORTH EAST

5-7 NOVEMBER 2025

Srimanta Sankaradeva Kalakshetra,
Exhibition Ground, Guwahati

Unleashing the Economic Potential of NER

Agro and Food Processing | Energy and Infrastructure | Health and Education
Tourism and Culture | Business and Trade | MSME and Entrepreneurship
Education and Social Development

For Sponsorship and Stall Booking Please Contact :

Mr. Tushar Sharma | *+91 – 8874184076* | *tushar.sharma@icfa.org.in*

Mr. Ankit Kumar | *+91 – 7290088227* | *ankit.kumar@icfa.org.in*

www.vibrantnortheast.in

Scan the QR

Regular Posting Date 27-28
Date of Printing 23
Post Office: Lodhi Road

DL(ND)-11/6128/2024-25-26
RNI No. 68745/98

SBI
The banker to every Indian

KISAN KI UNNATI SE HAI DESH KI PRAGATI.

SBI Agri Loan Products for your every agricultural need

AGRI GOLD LOAN
- Digital sanction on YONO KRISHI
- Low interest rate

KISAN CREDIT CARD
- Interest rate at 7% p.a., up to ₹ 3 Lakhs*
- 3% incentive for prompt paying farmers, up to ₹ 3 Lakhs*
- Collateral-free loan for up to ₹ 1.6 Lakhs

MUDRA LOAN
- No collateral up to ₹10 Lakhs
- Simple documentation

LOAN FOR SELF-HELP GROUPS
- Loan for livelihood
- Flexible repayment

AGRI ENTERPRISE LOAN
- Loan range: ₹1 Lakh - ₹100 Crores
- Covers all facilities, including fund-based and non-fund-based
- Features for exporters: EPC, PCFC, Post Shipment Credit, Bill discounting, etc

KISAN SAMRIDDHI RIN
- Higher loan limit for modern farming: ₹5 Lakhs - ₹50 Crores
- Open to all farmer types: Individual, Non-Individual, or Corporate

ATMA NIRBHAR BHARAT SCHEMES:
- Loans available under Agri Infra Fund, PMFME scheme, AHIDF scheme
- To establish cold storage, warehouses, silos, food processing units, etc.
- Credit Guarantee available
- Interest subvention available

FARMER PRODUCER COMPANIES (FPCs)
- Loans available for all activities of FPCs
- Attractive interest rates
- Credit guarantee available
- Interest concession available

T&C Apply

For more details, visit bank.sbi or contact Branch Manager

Follow us on