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A Resonance in Agriculture

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CARBON FARMING

Enhancing sustainability and resilience in agriculture

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From the Editor's Desk

Dear Readers,

It gives us great pleasure to present the June edition of **Times of Agriculture magazine**. This month, we bring into focus a subject of growing global relevance—**Carbon Farming**—an innovative and sustainable approach that holds the promise of not only revitalizing agriculture but also healing the planet.

Agriculture has always been the lifeline of human civilization, the very foundation of our existence. But today, our responsibilities extend far beyond food production. We now face the urgent challenge of protecting the health of our soils, preserving our natural resources, and combating the impacts of climate change. In this context, carbon farming emerges as a ray of hope an ecological intervention that marries tradition with innovation.

By enhancing the soil's ability to absorb and store atmospheric carbon dioxide, carbon farming strengthens the very fabric of our farmlands. It improves soil health, boosts water retention, and promotes biodiversity, while also contributing meaningfully to climate resilience. Most importantly, it is a movement powered by farmers—those who work closest with nature, and whose stewardship will shape the future of our food systems.

This issue not only explores the principles and practices of carbon farming, but also brings you the latest updates, expert insights, and inspiring stories from the field. Let this issue be a source of knowledge, reflection, and motivation as we collectively strive for a greener, more resilient agricultural future.

Thank you very much, and enjoy reading!

Editor-In-Chief

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CARBON FARMING

CONTENT

Times of Agriculture
A Resonance in Agriculture

AGRICULTURE UPDATES

Spices Board Launches SPICED Scheme to Boost Exports and Ensure Sustainability

The Spices Board of India, operating under the Ministry of Commerce and Industry, has unveiled a major initiative called the **SPICED scheme—'Sustainability in Spice Sector through Progressive, Innovative and Collaborative Interventions for Export Development'**. This strategic program is designed to boost India's spice exports, enhance productivity, and promote sustainable and innovative practices across the spice sector. The scheme will be in effect during the remaining years of the **15th Finance Commission cycle** and will continue until **2025–26**.

With a **total budget of ₹422.30 crore**, the SPICED scheme aims to bring systemic improvements to spice cultivation, including increased productivity in cardamom, better post-harvest management, and greater emphasis on value addition. The plan also includes special missions such as **Mission Value Addition**, **Mission Clean and Safe Spices**, and initiatives to promote **GI-tagged spices**. A major component involves the creation and strengthening of **Spice Incubation Centres** to foster innovation and entrepreneurship in the spice industry. In the financial year **2025–26**, around **₹130 crore** will be allocated to directly support approximately **45,000 beneficiaries**.

The scheme places special emphasis on **inclusive development**, giving priority to **farmer groups, Farmer Producer Organisations (FPOs), Farmer Producer Companies (FPCs), Self Help Groups (SHGs), Scheduled Castes (SC), Scheduled Tribes (ST), Small and Medium Enterprises (SMEs)**, and spice exporters from India's **North-Eastern states**. This inclusive approach is expected to uplift marginal spice growers and integrate them more effectively into global value chains.

India is a leading producer and exporter of a wide variety of spices such as **pepper, cardamom, chili, ginger, turmeric, coriander, cumin, fennel, celery, nutmeg**, and **spice oils**. Notably, **chili, cumin, turmeric, ginger, and coriander** together make up **76% of the country's total spice production**. By targeting these high-volume products and improving quality and export competitiveness, the SPICED scheme is expected to bring long-term benefits to the Indian spice sector and reinforce India's reputation in the global spice market.

Kozhikode becomes first district in Kerala to declare official biodiversity icons

In a pioneering move to honour its ecological richness, **Kozhikode** has become the **first district in Kerala** to designate **official emblem species** across eight biodiversity categories. This initiative, blending **scientific consultation** with **community participation**, reflects a new model of environmental stewardship and was announced as part of the **2024–25 Annual Plan** of the **Kozhikode District Panchayat**, in collaboration with the **Kerala State Biodiversity Board**.

Among the declared species, **Athirani (Melastoma malabathricum)** has been named the **official district flower**, while the dazzling **Oriental Dwarf Kingfisher (Ceyx erithaca)**, locally known as **Meniponman**, now holds the title of **official bird**. The **Malabar Rose (Pachliopta pandiyana)**, with its striking black and crimson wings, has fluttered into the role of **district butterfly**. In the tree category, **Eeyakam (Hopea erosa)** has been designated the **official tree**, and **Eenthu (Cycas circinalis)**, a species of deep ecological and cultural significance, has been honoured as the **heritage tree**.

Aquatic and terrestrial life has also found representation. The **Smooth-coated Otter (Lutrogale perspicillata)** was declared the **official aquatic animal**, while the **rare Pathala Poontharakan (Pangio bhujia)** was named the **district fish**. The **Indian Pangolin (Manis crassicaudata)**, a shy yet ecologically vital mammal, has been declared the **official district animal**.

The official announcement was made during a virtual ceremony inaugurated by **Forest Minister A. K. Saseendran**. The unique effort not only raises public awareness about local biodiversity but also sets a precedent for other districts in Kerala and beyond to follow in celebrating and protecting their native species through similar participatory approaches.

Bihar Hosts First-ever International Buyer-Seller Meet

In a major step toward enhancing Bihar's footprint in global agri-food markets, the **Ministry of Food Processing Industries (MoFPI)**, in collaboration with the **Government of Bihar**, **APEDA**, and the **Trade Promotion Council of India (TPCI)**, successfully hosted the **first-ever International Buyer-Seller Meet (IBSM)** at **Gyan Bhawan, Patna**. The two-day event marked a significant milestone for the state, offering a direct platform for its **MSMEs, Farmer Producer Organisations (FPOs)**, and **Self-Help Groups (SHGs)** to connect with international buyers and explore global trade opportunities.

The IBSM attracted a diverse group of stakeholders, including **over 70 international buyers** from **20 countries** such as the **UAE, Singapore, Japan, Ghana, Spain, Germany, and the UK**. Alongside them, more than **50 domestic buyers** and **20 institutional buyers** participated in the event. Over **500 structured B2B meetings** were conducted, enabling Bihar's producers and processors to showcase their value-added offerings like **GI-tagged makhana (fox nut), Shahi litchi, Zardalu mango**, and **Katarni rice**. These interactions provided many local enterprises with tangible export leads and opened new avenues for their integration into global value chains.

One of the key outcomes of the meet was the signing of a **Memorandum of Understanding (MoU)** between **APEDA, the Government of Bihar**, and **UAE-based Lulu Group**. This partnership focuses on extending the **shelf life and export potential of Bihar's famous litchis**, particularly Shahi litchi, and is expected to significantly enhance the state's horticultural export profile. The successful execution of IBSM is being seen as a transformative effort to align Bihar's agri-food sector with international demand, promote value-added exports, and empower local agri-entrepreneurs through global exposure and opportunities.

एपीडा
APEDA

Entomologists identify seven new moth species in Kerala

In a significant scientific breakthrough, **seven new species of moths** have been discovered in the **Ranipuram forest** of **Kasaragod district**, Kerala. The discovery, made by **entomologist Dr. Swafvan**, adds valuable insights to the growing documentation of Kerala's lepidopteran diversity and emphasizes the **rich biodiversity of the Western Ghats**.

The newly identified moths span across multiple families, including **Noctuidae, Crambidae, Erebidae, Pyralidae, Oecophoridae**, and **Tortricidae**, each known for distinct ecological roles. Dr. Swafvan noted that moths are often **underrepresented in biodiversity assessments**, especially in ecologically complex regions like **northern Kerala**, where diverse agroecosystems exist alongside forested areas. The study reinforces the importance of **forest habitats** in sustaining moth diversity, as these insects serve crucial ecological functions—as **pollinators, decomposers**, and an essential **food source for birds and other animals**.

The discovery was made using **vertical light traps** equipped with **two 65W CFL bulbs and a 160W mercury vapour lamp**, set against a **4 × 5 ft white cotton screen**—a proven method for attracting **nocturnal moth species**. This field methodology proved effective in documenting these elusive species, many of which may otherwise go unnoticed due to their cryptic nature and nocturnal behaviour.

The findings underscore the urgent need for **comprehensive biodiversity surveys** in the **Western Ghats**, one of the world's eight "hottest hotspots" of biodiversity. The study not only contributes to scientific understanding but also calls attention to the need for conservation strategies that include often-overlooked insect groups like moths. As climate change and habitat fragmentation continue to impact ecosystems, such discoveries are timely reminders of the ecological richness and fragility of India's forest landscapes.

Goa's Feni Secures First GI Process Certificate, Preserving Centuries-Old Tradition

In a landmark development for Goan heritage, the iconic **cashew-based liquor feni** has received its **first Geographical Indication (GI) process certificate**, awarded to **Cazcar Distillery** in **Bicholim**. This certification marks a crucial step toward safeguarding the authenticity of **feni**, a traditional spirit deeply embedded in Goa's cultural identity. The move not only recognizes the product's regional uniqueness but also helps secure its status in domestic and international markets.

Feni's history dates back to the **1600s**, when **Portuguese missionaries introduced the cashew plant** and distillation techniques to Goa. The knowledge was quickly adopted by the local populace, eventually transforming into a thriving **cottage industry**. Those who mastered the craft were known as **Bhatikars**, and they traditionally distilled the liquor in **earthen pots** called *bhatis*. Initially, the juice was extracted by stomping cashew apples with bare feet—an artisanal method that has now evolved into a **fully mechanised process**.

The production of feni involves **natural fermentation** of cashew apple juice for **72 hours**, followed by **two stages of distillation**. The **first distillate**, called **urak**, is a milder version of the liquor. When urak is redistilled—often blended with some fresh juice—it becomes **feni**, a stronger and purer spirit. True to its traditional roots, feni is **bottled without dilution**, maintaining an **alcohol by volume (ABV) of 40–43%**. This meticulous method of preparation is key to its distinctive aroma, flavour, and cultural value.

The GI process certification is expected to boost **brand protection**, encourage **responsible commercialization**, and ensure that **authentic Goan feni** retains its original character. As Goa continues to promote its rich food and drink heritage globally, this milestone brings renewed recognition to a drink that has remained **an essential part of Goan life for over four centuries**.

Centre reduces Basic Custom duty (BCD) on major imported Crude edible Oils from 20% to 10%

In a significant policy move to control rising edible oil prices, the **Central Government has reduced the Basic Customs Duty (BCD)** on **crude sunflower, soybean, and palm oils** from **20% to 10%**. This change increases the **import duty differential** between crude and refined edible oils from **8.75% to 19.25%**, a strategic measure aimed at enhancing **domestic refining capacity** and providing **relief to consumers** burdened by high food inflation.

The decision comes in response to the surge in edible oil prices triggered by the **September 2024 duty hike** and escalating **international market rates**. By lowering the duty on crude oils, the government aims to **reduce the landed cost and retail prices** of these essential commodities. The **Ministry of Consumer Affairs, Food and Public Distribution** has also issued an advisory to **edible oil associations and industry stakeholders**, urging them to **pass on the full benefit of the duty cut to consumers**, thereby ensuring immediate impact on household budgets.

The widened duty gap is expected to **discourage imports of refined oils** like **Palmolein**, while **redirecting demand toward crude variants**, particularly **Crude Palm Oil**. This shift will **stimulate domestic refining**, improve **capacity utilization**, and provide **fair market opportunities** for Indian refiners. Additionally, it will help maintain **fair compensation for farmers** by ensuring that value addition remains within the country.

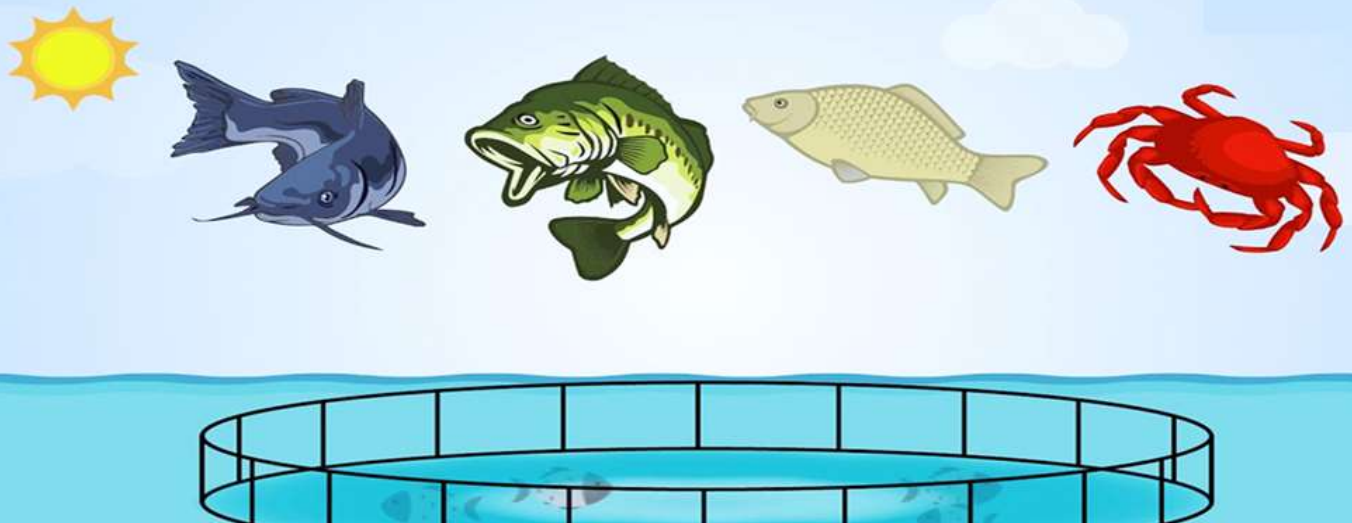
This policy intervention serves multiple objectives: **curbing inflation**, **supporting domestic industry**, and ensuring **price stability** for consumers. By promoting the import of crude rather than refined edible oils, the revised duty structure helps create a **more self-reliant and competitive refining sector**. It is expected to have a positive ripple effect across the **supply chain**, ultimately benefiting **both produeers and end consumers** in India.

Centre Organised Inland Fisheries & Aquaculture Meet 2025 in Indore

On **June 13, 2025**, the **Department of Fisheries**, under the **Ministry of Fisheries, Animal Husbandry and Dairying**, successfully organised the **Inland Fisheries & Aquaculture Meet 2025** in **Indore, Madhya Pradesh**. The event aimed to promote the development of **inland fisheries** and **sustainable aquaculture** in India. It was chaired by **Union Minister Rajiv Ranjan Singh**, with **Madhya Pradesh Chief Minister Dr. Mohan Yadav** and several senior officials and stakeholders in attendance.

During the event, the government **launched and laid the foundation stone for fisheries projects worth ₹52 crore** across **seven inland states and Union Territories** under the **Pradhan Mantri Matsya Sampada Yojana (PMMSY)**. The meet also featured the **distribution of Kisan Credit Cards (KCCs)**, **aquaculture insurance**, and **certificates** to **fisheries cooperatives, Farmer Producer Organisations (FFPOs)**, and **start-ups**. These initiatives were aimed at empowering **small-scale fishers** and enhancing **financial and digital inclusion** in the fisheries sector.

The Ministry highlighted the sector's remarkable progress over the last decade. **Total fish production increased by 104%**, from **95.79 lakh tonnes in 2013–14** to **195 lakh tonnes in 2024–25**. Significantly, **inland fisheries and aquaculture** accounted for **over 75% of the total output**, with inland production alone witnessing a **140% rise to 147.37 lakh tonnes**. The event underscored the government's continued commitment to boosting rural livelihoods, strengthening the fisheries value chain, and positioning India as a global leader in aquaculture.



COVER STORY

CARBON FARMING

Enhancing sustainability and resilience in agriculture

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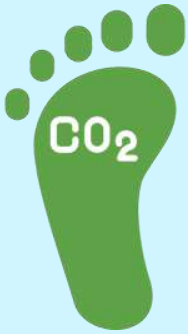

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Indian agriculture has undergone intense cultivation practices for the past six decades to ensure food security in the country. This has resulted in significant loss of soil organic carbon, deterioration of soil fertility and chemical pollution in major cultivated lands across the country. Further, intensive cultivation together with mono-crop cultivation of major cereals led to the loss of biodiversity and exhaustion of ground water resources. These cultivation practices have also led to an increase in greenhouse gas (GHG) emissions that contributes to global warming and climate change. In light of escalating environmental concerns and the pressing need for climate resilient agricultural practices, carbon farming has emerged as a crucial mechanism within the agriculture sector globally. Carbon (C), present in all living organisms and numerous minerals, serve as a cornerstone of life on earth, exerting significant influence over diverse processes such as photosynthesis and respiration; farming involves caring for the land, growing crops, and raising animals for food. The term "carbon farming" refers to a variety of land use and land management techniques intended to lower agricultural emissions or fix carbon in natural sinks like soil and plants (Pathak et al., 2021). However, there is no single definition. It can be defined as a system of increasing C in terrestrial ecosystems for adaptation and mitigation of climate change to enhance ecosystem goods and services, and trade carbon credits for economic gains. Large-scale carbon farming has been advocated by some to be the best option for stabilizing or reducing atmospheric CO_2 levels.

The main aim of Carbon farming is maximizing carbon sequestration and employing agricultural practices designed to enhance the absorption of carbon dioxide (CO_2) from the atmosphere while facilitating its retention in both plant biomass and soil organic matter. Soil C sequestration is a win-win strategy that enhances food production and increases climate change mitigation (Srinivasarao et al., 2013). The entire amount of greenhouse gases (CO_2 and CH4) produced by human actions is known as a carbon footprint.

Significance of Carbon farming

1. **Climate Change Mitigation:** While Indian agriculture is adversely impacted by the vicissitudes of climate change, the sector also is a significant contributor to greenhouse gas (GHG) emissions. As per the Third National Communication (TNC) Report submitted by the Government of India (GOI) in 2023 to the United Nations Framework Convention on Climate Change (UNFCCC), the agriculture sector contributes 14 per cent of the total GHG emission. Within the agriculture sector, 54.6 per cent of GHG emissions were due to enteric fermentation, followed by 17.5 per cent from rice cultivation, 19.1 per cent from fertilizer applied to agricultural soils, 6.7 per cent from manure management, and 2.2 per cent due to field burning of agricultural residues. Therefore, effective mitigation measures and appropriate adaptation technologies like carbon farming must be taken to reduce GHG emissions from the agriculture sector. Thus, Carbon farming is the key strategy in fight against climate change by reducing greenhouse gas emissions and storing carbon in the soil by carbon sequestration
2. **Soil Health Enhancement:** Quantity, quality, and dynamics/turnover of SOC are critical to soil health. Threshold level of SOC in the rootzone is 1.5–2.0%. Maintenance of SOC pool at above the threshold/critical level is essential to maintain:
    i. soil structure and aggregation which govern soil tilth and aeration;

ii. water retention and use efficiency which control tolerance to drought, heat wave, and abrupt climate change;

iii. nutrient retention and use efficiency which moderate nonpoint source pollution, water quality, and toxic algal blooms;

iv. rhizospheric processes which influence elemental transformations and creation of disease-suppressive soils; and

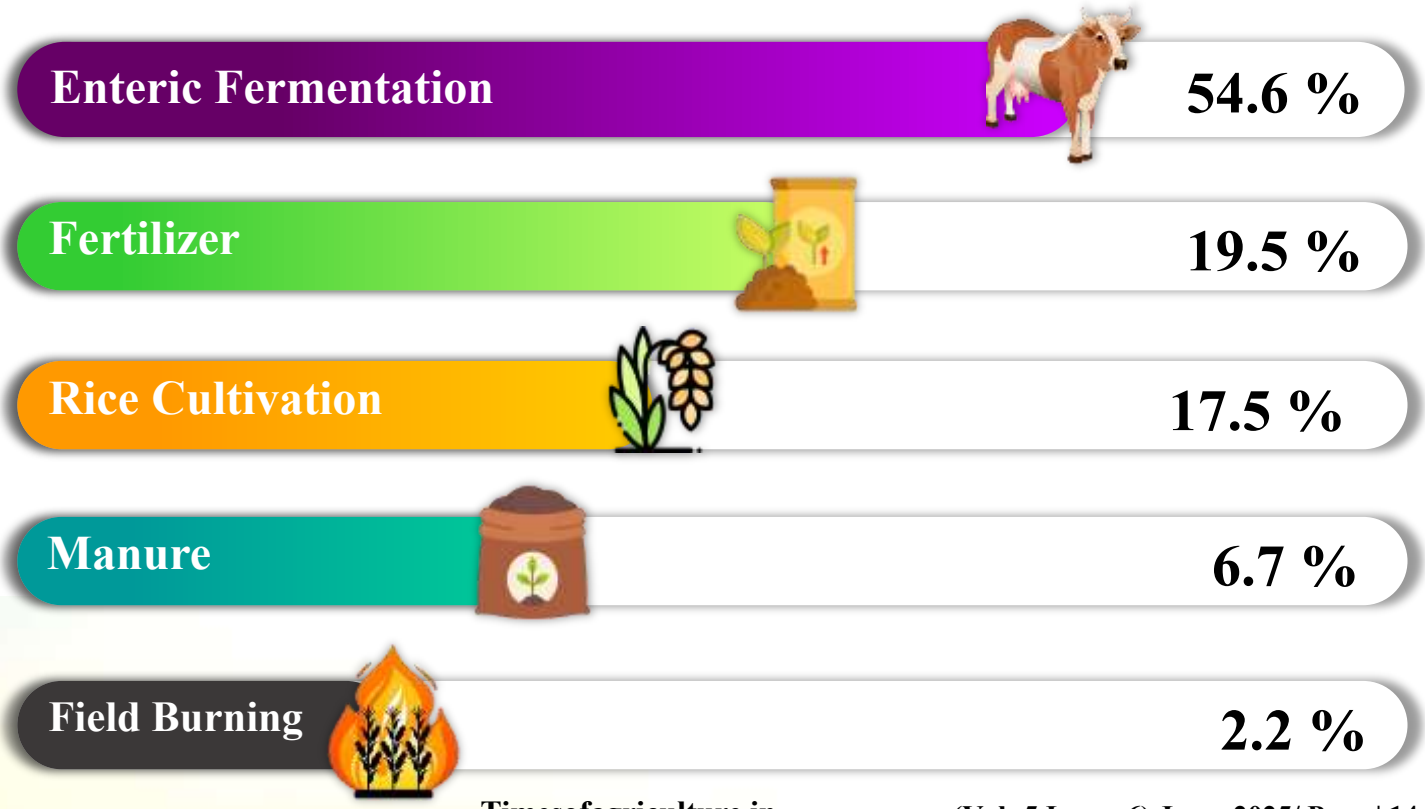
v. gaseous emissions (e.g., CO_2, CH_4, N_2O) which moderate atmospheric chemistry and regulate climate change.

Above all, numerous soil related properties contributing to agronomic productivity can also be alleviated through enhancement and sustainable management of the SOC pool by Carbon farming. By nurturing healthy soil, carbon farming bolsters water retention, diminishes erosion, and boosts nutrient availability, resulting in amplified crop yields and agricultural productivity.

4. **Biodiversity Enrichment:** Carbon farming fosters biodiversity by fostering intricate ecosystems in agricultural settings, attracting beneficial insects and pollinators that fortify crop health and lessen dependence on pesticides.

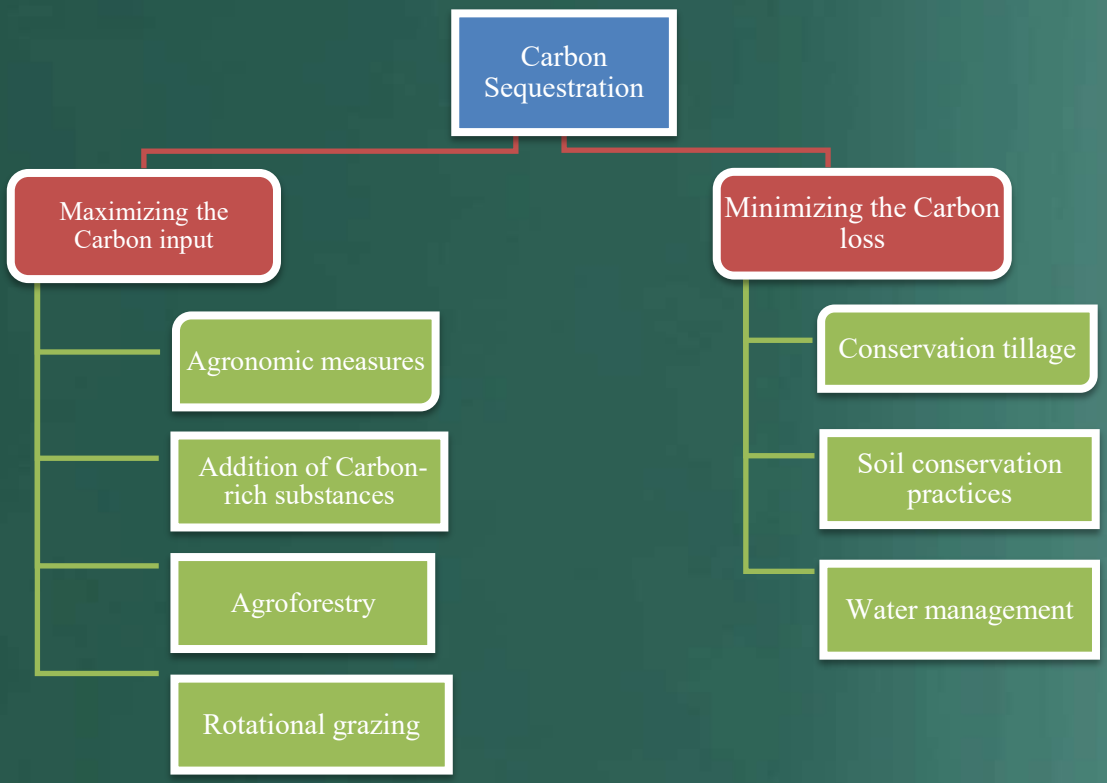
5. **Economic Opportunities:** Implementation of carbon farming practices opens avenues for farmers to tap into carbon credit markets, alongside potentially augmented yields from enriched soil, thus diversifying income streams and bolstering financial resilience.

GHG emissions in Agriculture



Strategies for carbon sequestration:

Carbon sequestration can be done by two ways as follows-

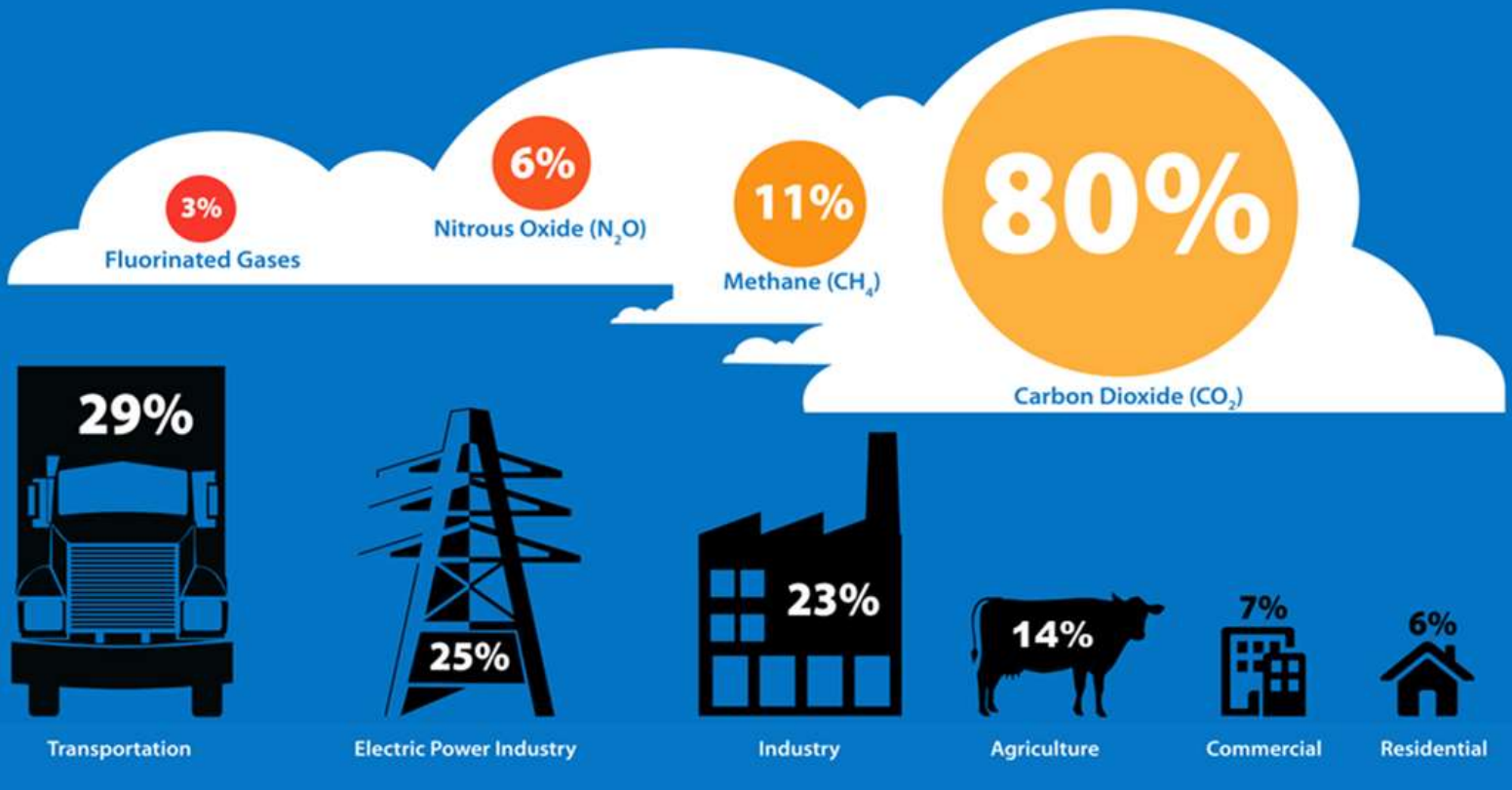


Different methods of carbon farming practices

1. **Agroforestry:** Farming with the intentional integration of trees with agriculture is known as agroforestry. Agroforestry practices can help mitigate emissions and store carbon in both soils and trees. Not only does agroforestry provide above-ground benefits in the field but it also provides crucial below-ground benefits. Out of different carbon farming practices, Agroforestry have Highest Carbon sequestration potential due to its perennial nature. It does this while also enhancing farm productivity, increasing soil protection, improving air and water quality; providing wildlife habitat, and introducing diversified income.
2. **Conservation agriculture:** Conservation agriculture offers solutions to such pernicious problems with good agronomy and soil management such as no-till farming, crop rotation, *in-situ* crop harvest residue management / mulching, zero-till planters such as the Happy Seeder, among others. These practices could be very useful in significantly reducing GHG emissions and fossil fuel consumption.
3. **Rice cultivation management:** Rice is main staple food crop in India which contributes to 17.4 % of total greenhouse gas (GHG) emission. It is essential to maintain productivity against climate change by adopting carbon farming practices like Direct seeded Rice and Alternate wetting and drying. DSR is reducing the methane emissions by 30–38% in India. IPCC 2006 Guidelines for National Greenhouse Gas Inventories estimate a 48% reduction in methane emissions from AWD. Additionally, crop

diversification from rice to nutritious and climate-resilient crops such as Millets and Pulses reduce the GHG emission and improve the nutritional value of the food system.

4. **Biochar application:** Biochar, produced from biomass through pyrolysis, can contribute to soil carbon sequestration. Recent analysis shows up to 33% increase in SOC with biochar application (Gross et al., 2021). Biochar may help not only in mitigating climate change, but also fulfill in management of agricultural and forestry wastes, enhancement of soil sustainability.
5. **Organic farming:** Chemical inputs reduce the capacity of soils to sequester carbon and can be wasteful when applied in excess. With prices going sky-high, manufacturing inorganic fertilizers also release a lot of greenhouse gas emissions. Therefore, Organic farming is the best method for reducing GHG emissions and improving organic carbon sequestration. This system eliminates synthetic nitrogen fertilizers and thus could lower global agricultural GHG emissions. Organic farming could result in a higher soil organic carbon content compared to non-organic systems.
6. **Renewable energy production**: India's ambitious renewable energy target (500 GW by 2030) must include the potential agriculture sector upfront. Renewable energy facilities, such as wind or solar, generate carbon offsets by displacing fossil fuel-based electricity production sources within the power grid. Reducing energy usage from fossil fuel sources and moving towards renewables, will reduce carbon footprints in the agriculture sector and enhance livelihoods of smallholders.
7. **Reduced tillage:** Frequent and heavy tilling increases the rate of carbon dioxide released from the soil. In the process, it also breaks up soil structure which can lead to erosion and less productive croplands. Regenerative tillage, which is done at minimum or no-tillage at all, preserves soil quality and carbon that has benefits to crop yield.
8. **Forest management:** Healthy forests absorb and hold carbon dioxide emissions produced from other sources and are an important source of greenhouse gas (GHG) sequestration.



Improved forest management focuses on long-term, sustainable practices to ensure that forests continue to remove CO_2 from the atmosphere since deforestation accounts for between 15 and 20 percent of the global increase in GHG levels. Activities include thinning out, selective harvest, regeneration and planting, and fertilization to enable productive and sustainable forest growth.

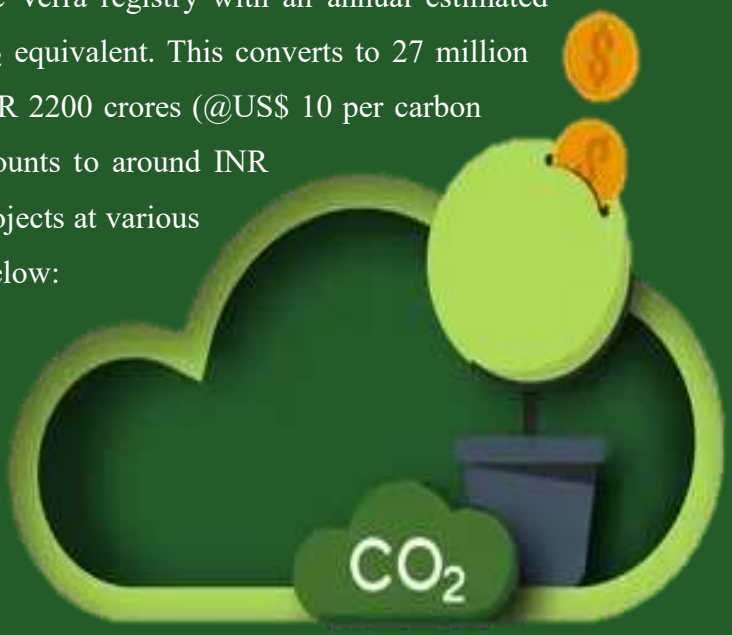
Carbon trading mechanism

Carbon trading is the process of buying and selling permits and credits that allow the permit holder to emit carbon dioxide. It is a market-based system aimed at reducing greenhouse gases that contribute to global warming, particularly carbon dioxide emitted by burning fossil fuels. Carbon trading started formally in 1997 under the United Nations Kyoto Protocol. Each carbon emission reduction (CER) is equivalent to one tons of CO_2 reduction. Such a credit can be bought and sold on the global market at the going rate.

According to a World Bank report (Nair and Nandkumar, 2013), India might end up being one of the biggest winners, accounting for more than 25% of the whole global carbon trade. India is now the second-largest supplier of carbon credits as a result. At the present market rate, a farmer who sequesters one carbon credit can earn about INR 780, but major firms are anticipated to provide greater rates up to INR 2,000 to farmers when they directly purchase huge amounts of carbon credits. In addition, India's renewable energy industry, which includes wind and solar energy, provides chances for producing carbon credits through clean energy initiatives. India's extensive agricultural base presents significant economic opportunities through the adoption of carbon farming practices with an estimated potential of $63 billion from approximately 170 million hectares of arable land. This estimate includes an annual payment of around ₹5,000-6,000 per acre for farmers to provide climate services by adopting sustainable agricultural practices. According to the Ministry of Environment, Forest and Climate Change of India, India would gain at least $5 billion to $10 billion (Rs 22,500 crore to Rs 45,000 crore) through carbon trading over time.

Carbon farming projects in India

There are several initiatives on carbon farming in India mostly by private entities. More than 140 agriculture land management projects are listed in the Verra registry with an annual estimated emissions reduction of more than 27 million tons CO_2 equivalent. This converts to 27 million carbon credits, the value of which might be around INR 2200 crores (@US$ 10 per carbon credit). Assuming 60% of this reaches farmers, it amounts to around INR 1300 crores (Cariappa, 2023). A few carbon farming projects at various stages of registration listed in Verra registry are given below:



Project name	Location	Interventions	Annual estimated emissions reduction (tCO_2e)	Duration of the project
Agricultural land management	Beed District of Maharashtra	Tree plantations, differential cropping patterns, vermicomposting etc.	33764	2017-2037
Horticulture plantation in Central India	Madhya Pradesh	Planting, nurturing, and management of horticultural fruit bearing species including guava, orange, lemon, etc.	115000	2021-2041
Incentivizing smallholder farmers to transition to low-emissions agriculture and agroforestry	Central Plateau, Southern Plateau, and East Coast Plains region of India	Dry-Direct Seeded Rice (DSR), Wet-DSR, and Alternate Wetting and Drying (AWD) for paddy, zero tillage, cover cropping, crop residue management, improved fertilizer practices, green manuring, and agroforestry	463650	2022-2032
Improved agricultural practices for rice cultivation in India	Assam and West Bengal	Alternate Wetting and Drying (AWD)	217728	2023-2043
Maharashtra and Gujarat initiative for regenerative agriculture and income creation	Maharashtra and Gujarat	Fertilizer and water man agreement, cover crops, zero or reduced tillage, crop rotation, agro-forestry	4861245	2020-2040
Source- Voluntary Carbon Market in Indian Agriculture: Status, Challenges and Way Forward policy paper 2025 by ICAR-CRIDA, Hyderabad				

Conclusion

Given the increasing human demands and their impact on the environment, sustainable agricultural practices are becoming more crucial. Carbon farming emerges as a comprehensive and sustainable land-use management approach beneficial to both the environment and society. This practice is known for its potential in reducing greenhouse gas (GHG) emissions and sequestering carbon, which varies based on climate conditions, soil characteristics, and land-use practices. A number of promising technologies supporting carbon sequestration have evolved with time viz. agroforestry, conservation agriculture, AWD, DSR etc. Carbon trading via carbon credits offers a new source of income for farmers adopting sustainable practices. To effectively promote and scale up carbon farming in India, a comprehensive policy approach is essential. This should include financial incentives, carbon pricing mechanisms, research and development initiatives, capacity-building programs, and supportive land-use policies. By embracing carbon farming, India has the potential to contribute significantly to global climate goals, enhance food security, promote sustainable rural livelihoods, and improve environmental resilience.

■■■

SUCCESS STORY

FROM CORPORATE LADDER TO POMEGRANATE FARM

THE INSPIRING JOURNEY OF ROHIT CHOUDHARY

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Pomegranate cultivation worldwide has seen significant growth recently, driven by rising consumer awareness of its health benefits and demand for functional foods. Major producers include India, Iran, China, Spain, Turkey, and Egypt. India remains the largest producer, mainly in Maharashtra, Karnataka, and Gujarat, playing a crucial role in both domestic consumption and exports. Iran is known for high-quality varieties and is a key global supplier, while China's cultivation expansion aims to bolster its domestic and export markets. Spain and Turkey have also gained prominence, especially across Europe and the Middle East, providing fresh fruits and processed products. The global market was valued at around USD 4–6 billion in 2022 and is projected to grow annually by 5–7%, fuelled by increased health consciousness. The demand for pomegranate juices, extracts, and health supplements is surging, along with an interest in organic and wellness-oriented products. North America, particularly the U.S., is a major importer, while Middle Eastern countries are both producers and consumers. Expanding cultivation regions like the Mediterranean have added supply capacity. Overall, global demand remains strong, driven by health trends, processed product consumption, and wider cultivation zones.

India is the world's largest producer, with around 2.5 million tonnes annually (2022-23). Key states include Maharashtra, Karnataka, Andhra Pradesh, Telangana, and Tamil Nadu, with Rajasthan, is experiencing notable growth owing favourable climate, and rising demand. Rajasthan contributed about 156,844 tonnes across 17,165 hectares in 2022-23, with Barmer leading production at 102,112 tonnes. Other important districts are Jalore and Jodhpur. Supported by government initiatives like the Horticulture Mission, Rajasthan's industry benefits from increasing domestic and export demand, especially to Middle Eastern countries, the U.S., and Europe. Export value reached approximately USD 28 million recently. With rising consumption, expanding cultivation, and government support, Rajasthan is poised to become an important hub for pomegranate production in India, indicating promising growth prospects for the sector.

Rohit Choudhary's story is a testament to the transformative power of passion and courage. Armed with a postgraduate degree in History and an MBA, he spent nearly a decade in the corporate world, working with prestigious firms like ICICI Bank, Vodafone, and Tata Sky and there he was honoured with awards many times for his work efficiency. Yet, in 2017 a visit to his friend Mr. Vikramaditya Rathore's pomegranate farm in Jagsa village marked a turning point in his life.

Fascinated by the potential of agriculture, Rohit made a bold decision, he left his corporate career, although he was from Alwar district, acquired 24 Bigha land in Kundal village of Balotra district and embraced farming. His journey reflects the growing trend of urban professionals returning to their roots, driven by sustainability and innovation. Today, Rohit stands as an inspiring figure, proving that success is not confined to boardrooms but can blossom in the fields as well.

Transitioning from corporate life to farming was far from easy for Rohit. He encountered several challenges along the way, starting with the language barrier. Being new to western Rajasthan culture, he had to quickly learn the local dialect to communicate effectively with the community. Choosing the right crop was another hurdle; after consulting experienced farmers, he opted for the high-yielding 'Bhagwa Sindoori' variety, which was in high demand among buyers. Labor shortage posed a significant problem, as skilled workers were hard to find, forcing Rohit to train laborers himself. Additionally, the lack of government support during the initial stages left him without formal guidance, prompting him to turn to social media and digital platforms for knowledge and best practices. The absence of local soil and water testing facilities further complicated matters, making soil management particularly challenging in the beginning. Despite these obstacles, Rohit's disciplined efforts paved the way for his success. He ensured the procurement of high-quality plants from government recognized trusted nurseries, provided balanced nutrition and maintained healthy growth through regular root and plant pruning. Rohit planted 2700 plants in 24 Bighs in 2018 and invested almost 14 lakh rupees for 30 months, i.e. till the production had not started. He made a profit 24 lakhs from first harvest, after that now he makes a profit of almost 35 lakhs annually. His dedication paid off. In 2023, he achieved a remarkable yield of 35 kg per plant and secured Rajasthan's highest market rate of ₹141 per kilogram—surpassing the income he once earned in the corporate sector. Now he earned approximately lakhs annually from 5000 plants, depend on market value. Rohit says that farming has giving me money as well as health, peace of mind and a quality life.

Earlier Mr. Rohit received technical guidance about pomegranate cultivation from social media. YouTube tutorials, WhatsApp groups, and guidance from experts like Dr. Jyotsna (NRCP, Solapur (Maharastra)) and Mr. Nitin Ozarkar provided crucial insights. Their support helped him adopt best practices in pomegranate cultivation. From 2024, Mr. Rohit Chaudhary started working with a research project funded by Central Arid Zone Research Institute (CAZRI, Jodhpur) and established contact with a team of ICAR-CAZRI scientists Dr. O.P. Meena, Dr. Dheeraj Singh, Dr. Pramendra, Dr. Dipika Hajong and Dr. S.P.S. Tanwar. From this, Mr. Rohit received valuable solutions to address some faulty practices in pomegranate cultivation. He quickly implemented these recommendations, mainly related to management of orchard during rest period and is now prepared to expand his pomegranate farming using the latest interventions, such as high-density plantation with tissue culture plants. He emphasized that with proper scientific guidance, farmers have a real opportunity to double their income. He believes that farming with scientific methods not only helps conserve natural resources but also saves time and reduces additional expenses in cultivation. This approach, he asserts, is essential for sustainable and profitable pomegranate farming.

Rohit's journey proves that pomegranate farming, though challenging, is highly rewarding if done systematically. His advice to fellow farmers: "Adopt scientific methods, stay patient, and success will follow." His story is a testament to perseverance and innovation in modern agriculture.

■■■

CLIMATE-SMART SEEDS

ADVANCEMENTS AND IMPLICATIONS FOR SUSTAINABLE AGRICULTURE

About Author

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Climate change poses significant challenges to global agriculture, necessitating the development of resilient crop varieties. In India, where agriculture is predominantly rain-fed and highly susceptible to climatic variations, the adoption of climate-smart seeds has become imperative. These seeds are engineered to withstand abiotic stresses such as drought, heat, and salinity, thereby ensuring food security and enhancing farmer livelihoods.

Recent developments in climate-smart seed varieties

The Indian Council of Agricultural Research (ICAR) has made substantial progress in developing climate-resilient crop varieties. In August 2024, Prime Minister Narendra Modi launched 109 new high-yielding, climate-resilient, and bio-fortified seed varieties across 61 crops, including cereals, millets, pulses, oilseeds, and horticultural crops. Notable among these is CR Dhan 416, a rice variety suitable for coastal saline areas, with a yield potential of 48.97 quintals per hectare and resistance to multiple pests and diseases.

Furthermore, between 2014 and 2024, ICAR developed approximately 2,900 high-yielding, climate-resilient crop varieties, with 537 specifically tailored for extreme climatic conditions using precision phenotyping tools. These advancements underscore India's

Figure 1: Field view of CR Dhan 416 rice variety adapted to saline coastal areas, showcasing its climate-resilient traits. Source: Krishijagran.

Figure 2: Farmers participating in seed distribution activities under the Seed Village Programme, aimed at promoting climate-smart seed adoption. Source: RGVN.

commitment to enhancing agricultural resilience through scientific innovation.

Adoption and impact on agricultural practices

The adoption of climate-smart seeds has shown promising results. During the 2024 Kharif season, the government aimed to cover 25% of the paddy area with climate-resistant varieties, building upon the success in the Rabi season where nearly 75% of the wheat area was sown with such varieties. This strategic approach has contributed to record wheat production, estimated at 113 million tonnes for the 2024-25 marketing season.

The integration of these varieties into farming systems has led to improved yield stability, reduced input costs, and enhanced nutritional quality of crops. For instance, biofortified varieties have been linked to government initiatives like the Mid-Day Meal Scheme and Anganwadi services to combat malnutrition in India.

Challenges and future directions

Despite the progress, several challenges hinder the widespread adoption of climate-smart seeds. These include limited awareness among farmers, inadequate seed distribution networks, and resistance to adopting new technologies. To address these issues, the government has implemented the Seed Village Programme under the Sub-Mission on Seed & Planting Material (SMSP), aiming to supply climate-resilient, bio-fortified, and high-yielding seeds to farmers at the village level.

Looking ahead, the focus will be on enhancing seed delivery mechanisms, increasing farmer education through Krishi Vigyan Kendras (KVKs), and fostering public-private partnerships to accelerate the development and dissemination of climate-smart seeds.

Conclusion

The development and adoption of climate-smart seeds are pivotal in ensuring sustainable agricultural practices in the face of climate change. Continued investment in research, infrastructure, and farmer education will be essential to realize the full potential of these innovations, thereby securing food systems and improving the livelihoods of farmers across India.

■■■

FARMING WITHOUT SOIL

MYTHS vs. FACTS ABOUT HYDROPONICS IN INDIAN CONDITIONS

About Author

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Soil is everything to a farmer. For thousands of years, Indian farmers have been tilling the earth, planting seeds, and hoping for good monsoons. The rich, dark soil has served as the backbone of agriculture across our diverse landscapes, from the wheat fields of Punjab to the spice gardens of Kerala. But what if we told you that some of the freshest, most nutritious vegetables are now being grown without a single grain of soil? Hydroponics, the fascinating blend of art and science that allows plants to thrive in water, is transforming farming throughout India. However, even with its rising popularity, this soil-free method is often clouded by myths, misconceptions, and half-truths that can hold farmers back from tapping into its full potential.

The reality check

Take a stroll through any bustling market in Delhi, Mumbai, or Bangalore today, and you'll come across fresh lettuce, ripe tomatoes, and fragrant herbs that have never seen the earth. These plants thrive in nutrient-rich solutions, their roots suspended in the air, yielding results that would leave traditional farmers in awe. While this technique isn't exactly new think of the ancient Hanging Gardens of Babylon, it's making quite a splash in modern Indian agriculture.

Myth 1: "Hydroponics is too expensive for Indian farmers"

The myth:

A lot of folks think that hydroponic farming demands huge investments that only affluent commercial farmers can manage.

The reality:

Sure, the initial setup might cost more than traditional farming, but the numbers tell a different tale. You can set up a basic hydroponic system for leafy greens for around ₹50,000-₹1, 00,000 per 1000 square feet. When you compare that to the lakhs you'd spend on agricultural land in peri-urban areas, it starts to look pretty reasonable.

Take Rakesh Sharma, for instance. This former IT guy from Pune kicked off his hydroponic farm with just ₹2 lakhs. Now, he's churning out 500 kg of veggies every month, raking in profits of ₹40,000-₹50,000. His water bill is 90% lower than what traditional farming would cost him, and he doesn't shell out cash for pesticides, fertilizers, or soil amendments.

The key is starting small and scaling up. Many successful hydroponic farmers began with

kitchen gardens, growing herbs and leafy vegetables for family consumption before expanding commercially.

Myth 2: "Plants need soil to be healthy and nutritious"

The myth:

Many people believe that soil is the only way to provide essential nutrients to plants, leading to the idea that produce grown in soil is inherently more nutritious.

The reality:

Research has shown time and again that vegetables grown hydroponically can actually have higher levels of vitamins, minerals, and antioxidants than those grown in soil. This is because farmers can fine-tune the nutrient delivery, giving plants exactly what they need at the right time.

For instance, Dr. Murtaza Hasan's research at the Indian Agricultural Research Institute revealed that hydroponically grown lettuce had more iron and vitamin C than conventionally grown spinach. The controlled conditions of hydroponics also mean less competition from weeds and reduced stress from soil-related diseases, allowing plants to channel their energy into nutrient production instead of just surviving.

Myth 3: "Hydroponics won't work in Indian climate"

The myth:

India's diverse and often extreme climate conditions – from scorching summers to heavy monsoons – make hydroponics impractical.

The reality:

Indian climate diversity actually favors hydroponics in many regions. The technique works exceptionally well in controlled environments, protecting crops from weather extremes that devastate traditional farming.

In Rajasthan's desert regions, hydroponic farms produce fresh vegetables year-round using 95% less water than conventional farming. During Mumbai's monsoon season, when traditional farms struggle with waterlogging and fungal diseases, hydroponic systems continue producing healthy crops in protected environments.

Bangalore's pleasant climate allows outdoor hydroponic systems to operate without expensive climate control, making it one of India's hydroponic capitals. Even in harsh conditions, simple shade nets and basic environmental controls create suitable growing conditions.

Myth 3: "Hydroponics won't work in Indian climate"

The myth:

Many believe that India's varied and often extreme weather, from blistering summers to torrential monsoons makes hydroponics impractical.

The reality:

In fact, the diverse climate across India can actually be a boon for hydroponics in several areas. This method thrives in controlled settings, shielding crops from the

harsh weather that can wreak havoc on traditional farming.

Take Rajasthan's desert regions, for example, where hydroponic farms can grow fresh vegetables all year round while using 95% less water than conventional methods. And during the monsoon season in Mumbai, when traditional farms face challenges like waterlogging and fungal issues, hydroponic systems keep churning out healthy crops in their protected environments.

Bangalore, with its lovely climate, is another hotspot for hydroponics, allowing outdoor systems to flourish without the need for costly climate control. Even in tougher conditions, a simple shade net and some basic environmental adjustments can create the perfect growing atmosphere.

Myth 5: "Hydroponic vegetables don't taste as good"

The myth:

People often believe that vegetables grown without soil just can't match the rich flavors of those grown in the earth.

The reality:

Taste tests reveal a different story; many consumers actually prefer the taste of hydroponically grown veggies! Thanks to controlled growing conditions, farmers can enhance both flavor and nutritional value.

In Mumbai, top-notch restaurants are on the lookout for hydroponically grown herbs and microgreens, drawn in by their bold flavors and reliable quality. Take cherry tomatoes, for instance, those grown hydroponically tend to be sweeter because farmers can fine-tune sugar levels with precise nutrient management. Plus, without soil-borne contaminants, these veggies can be picked at their peak ripeness, unlike traditional farming where early harvesting is often necessary for long-distance transport.

The Indian success stories

Across India, hydroponic innovators are turning skeptics into believers. In Kerala, the state government is backing hydroponic farming as a smart solution to land shortages. Meanwhile, farmers in Tamil Nadu are using coconut coir, a locally available waste product as a growing medium, which cuts costs and supports a circular economy.

Urban entrepreneurs in tier-2 cities are setting up hydroponic farms to provide local restaurants and supermarkets with top-quality produce. These farms often yield 3-5 times more per square foot than traditional methods; all while using 90% less water.

Challenges that remain real

Despite dispelling some myths, hydroponics in India still faces real challenges. Small farmers often struggle with the initial investment costs, but thankfully, microfinance options and government programs are stepping in to help bridge that gap. Unfortunately, technical support and training are still pretty scarce in rural areas, highlighting the need for better extension services.

Inconsistent power supply can also throw a wrench in automated systems, making backup solutions or manual overrides necessary. But with the right planning and community backing, these hurdles can definitely be overcome.

Conclusion

Farming without soil isn't just a possibility in India, it's actually thriving. Despite some lingering myths, the reality is that hydroponics is stepping up to tackle significant agricultural challenges. This method isn't here to replace traditional farming; instead, it's working alongside it, offering farmers new options in the face of water shortages, limited land, and unpredictable climate conditions.

The trailblazers of hydroponics in India aren't just tech-savvy entrepreneurs; they're practical farmers looking for smarter ways to produce food. Their success stories highlight that with the right knowledge, support, and a bit of grit, soil-free farming can flourish in the varied landscapes of Indian agriculture.

As water becomes scarcer and populations continue to rise, the real question isn't if hydroponics will take off in India, but rather how quickly farmers will jump on this soil-free bandwagon.

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ECONOMIC IMPORTANCE OF VALORIZING WASTE

FOR BIOACTIVE EXTRACTION THROUGH ULTRASOUND EXTRACTION TECHNIQUE

About Author

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Fruits and vegetables are essential in the horticultural industry due to their significant commercial value. They are used either in their natural state or processed, as they contain beneficial compounds that promote health. The processing of these items results in the generation of a substantial amount of waste, with peel waste making up the majority (approximately 70%) of this waste. Typically, waste materials contain a substantial quantity of bioactive compounds. The primary goal is to isolate these valuable substances for optimal utilization of waste peels. The process of extracting bioactive compounds from discarded fruit and vegetable peels, focuses on a range of extraction techniques using traditional and innovative methods. The techniques covered include microwave-assisted extraction, ultrasound-assisted extraction, pulsed electric fields, pulsed ohmic heating, pressurized liquid extraction, supercritical fluid extraction, pressurized hot water extraction, high hydrostatic pressure extraction, dielectric barrier discharge plasma extraction, enzyme-assisted extraction, and the use of environmentally friendly solvents. The importance of utilizing advanced extraction techniques to increase the value of readily available and inexpensive waste peels, to create cost-effective alternatives that promote environmental sustainability and the advancement of a circular economy. The insights presented in this article could serve as a valuable resource for the fruit and vegetable processing industry to adopt efficient and sustainable extraction methods, turning waste peel remnants into valuable functional products.

Biological techniques and Bioactive compounds

Biological techniques provide several benefits because of their selectivity, such as the ability to produce extracts with high bioactivity and purity and low toxicity. Numerous food waste

materials can yield bioactive compounds. For example, cereal bran, which is rich in flavonoids, glucans, pigments, and phenolic compounds; fruit and vegetable wastes, which have been shown to contain phenolic compounds and complex carbohydrates and animal wastes, such as fish wastes that are high in omega 3 and milk processing wastes, which have been shown to contain peptides. In many cases, the concentration of bioactive compounds has been reported more in these by-products than in the edible part of the fruit. For example, the concentration of the phenolic compound is 15% higher in peels of lemons, grapes, oranges and seeds of avocado, jackfruit, and mangoes than in the pulpy part of the fruit. The health benefits of these compounds include anti-allergenic, anti-inflammatory, anti-microbial, anti-oxidant, antithrombotic, cardioprotective, and vasodilatory effects. The valuable bioactive compounds, which should be utilized for the development of functional or enriched food, are lost in want of economically viable extraction techniques. Agro-industrial wastes encompass a range of bioactive compounds, some of which are particularly relevant for use in the food and pharmaceutical industries. These substances include bioactive peptides, phenolic compounds, polysaccharides, and other molecules with unique biological and technical qualities. Ultrasounds are successfully employed for the extraction of polyphenols, carotenoids, aromas, and polysaccharides from plant matrices (whole plant and by-products). The variables associated with UAE such as frequency, power, duty cycle, temperature, time, solvent type, and liquid-solid ratio need precise control for optimum extraction. The individual, as well as interactive effects of these variables have been studied by several researchers on the extraction of bioactive compounds from fruit and vegetable by-products.

Concept and mechanism of UAE

Ultrasound-assisted extraction (UAE) uses ultrasound energy and solvents to extract target compounds from various plant matrices. Ultrasound is a mechanical wave having a frequency (>20 kHz) higher than the audible frequency range of human hearing (20 Hz to 20 kHz). These waves consist of a series of compression and rarefaction cycles that can be propagated through solid, liquid or gas medium inducing displacement and dislodgement of the molecules from their original positions. At high-intensity sound waves, the negative pressure during rarefaction exceeds the attractive force joining the molecules together pulling them apart and creating cavitation bubbles. These bubbles grow through coalescence and later collapse during compression phase creating hot spot and extreme local condition. The temperature may reach up to 5000 K and pressure increase may be up to 1000 atm.

Acoustic cavitation is the main mechanism involved in the ultrasound assisted extraction. The collapsing cavitation bubbles and the sound waves may induce either one or combination of the phenomena such as fragmentation, localised erosion, pore formation, shear force, increased absorption and swelling index in the cellular matrix of the plant. The collapsing cavitations bubbles generate shockwaves and accelerated inter-particle collision causes the fragmentation in cellular structure. The rapid fragmentation leads to solubilisation of the bioactive component in the solvent due to decrease in particle size, increased surface area and high mass transfer rates in the boundary layer of solid matrix. Ultrasound leads to the localized damage to the plant tissues termed as erosion. This erosion may also be attributed to the implosion of the cavitation bubbles on the surface of plant tissues. The eroded part facilitates the contact of solvent, increasing the yield of extraction. The formation of pores during cavitation, a phenomenon knows as ‘sonoporation’, in the cell membranes results in the release of the bioactive compounds present in cell. In addition to that, the generation and collapse of cavitation bubbles induces shear force and turbulence within the fluid, which results in breakdown the cell walls contributing to releasing the bioactive compound. Ultrasound also increases the swelling index of plant tissue matrix which helps in both desorption and diffusion of solutes, resulting in increased extraction.

Application of UAE extraction of pectin

The presence of pectin in the cell wall and middle lamella of many plants, including fruits and vegetables, has encouraged researchers to exploit waste peel, pomace and rind of the plant for the extraction of pectin from them. Peel of fruits such as pomegranate, orange, banana, grapefruit, mango, passion fruit, vegetables such as eggplant, jackfruit and other parts such as tomato waste, grape pomace and sunflower head have been used to extract pectin.

Pectin yield above 25% through UAE has been obtained from pomegranate peel, grape pomace, tomato waste, grapefruit peel, orange peel and eggplant peel. The optimized condition for the UAE of pectin from different plant by-products is given. The yield of pectin depends on ultrasonic parameters such as frequency, power, duty cycle, power intensity, sonication time and extraction variables such as temperature, LSR, pH of solvent, either alone or their interactive effect. The UAE pectin extraction from the residue of phenolic compound extracted mango peel and observed 50% increase in yield (from 5.61 to 8.6) while the yield of UAE pectin from rehydrated mango peel increased by 31% (from 6.2 to 8.1) as compared to pectin extraction without ultrasound without affecting the quality of pectin. The characterisation of extracted pectin through UAE has been done to ascertain its quality and establish its properties. High methoxyl pectin (Degree of esterification >50%) has been extracted using ultrasound from eggplant peel, grape pomace, passion fruit peel, sunflower head, and grapefruit peel. The incomplete extraction of pectin in the first stage was attributed to the 'barrier effect' due to an increase in viscosity of the extraction mixture owing to an increase in pectin concentration in the mixture solution at a later period of the first stage extraction. The addition of water in the second stage helped to dissolve the remaining pectin, increasing the yield.

The UAE of bioactive compounds from fruit and vegetable by-products offers a huge advantage in terms of reduction in time, temperature, energy and chemical requirements in the extraction process. However, the complete elimination of chemical solvents in extraction with satisfactory yield needs to be achieved. The use of UAE in combination with other non-thermal extraction methods such as microwave-assisted extraction, enzyme-assisted extraction, and pulsed electric field-assisted extraction for the extraction of bioactive from fruit and vegetable by-products is limited and requires to be explored further. The development of equipment avoiding direct contact of components such as ultrasonic horns with the fruit and vegetables during extraction would enhance the commercial viability of the UAE of bioactive compounds, which is limited till now.

Conclusion

There are many more unutilized by-products where these concepts can be utilized, and recovery of valuable bioactive components can be made. The demand for the natural bioactive compound is increasing and UAE of the bioactive compounds from fruit and vegetable by-products can meet this demand through continuous improvement in technology and focused research.

Large volumes of agro-industrial residues are produced during the processing of animal and vegetable resources, making it critical to implement methods for the integrated use of residues or even their conversion into higher-valued products. Biological techniques have various benefits over nonbiological procedures, including the supply of extracts of high quality, high bioactivity, and low toxicity. Bioactive substances derived from biological byproducts may be used to make meals as well as active or smart agents for biodegradable materials and packaging, all while improving consumer health, food safety, and the sustainable use of natural resources.

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Previous Issues

Website Statistics (May 2025)

152K	60K	3.3M
Monthly Pageview	Monthly Visitor	Monthly Impression

Social Stats

6.5K	5.7K	9.2K	1.7K	2K

CARBON FARMING AND AGRI-TECH

PAVING THE WAY FOR SUSTAINABLE AGRICULTURE IN INDIA

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With the increase in global carbon emissions and resulting climate change, it becomes crucial to incorporate carbon-positive agricultural practices which would help sequester (store) carbon within the soil and biomass. Carbon farming refers to the agricultural practices and land management techniques which increase and encourage carbon sequestration. These include practices such as no-till, vegetable mulch, agroforestry, cover cropping, rotational grazing, crop rotation, biochar, etc. Carbon farming is associated with numerous benefits such as climate change mitigation, soil health improvement, generation of alternative income, building resilience as well as encouraging biodiversity.

Challenges in carbon farming

Carbon farming (CF) presents itself with a number of challenges, which needs to address for wider acceptability of the initiative.

1. Lack of awareness:

Majority of the farmers lack general awareness regarding the procedure and benefits associated with carbon farming. Often, the complex scheme-design and implementation of new farm management practices, acts as deterrents towards CF adoption. Furthermore, the fear of financial losses and tendency of risk aversion among small and marginal farmers limits CF usage.

2. Financial consequences:

Carbon farming is a cost-intensive venture, with high capital investment in the initial years. However, the instability of carbon markets, uncertainty regarding the selling price and its unsustainability with traditional practices are a cause of concern for the farmers. Additionally, regular estimation of carbon sequestered is an expensive venture as well.

3. Lack of homogeneous carbon quantification methods:

Although a number of techniques are used for measuring among of carbon sequestered, the methods rely of various forms of destructive sampling or allometric equations, which vary based on the species, climate, soil, age of the species, etc.

4. Regulatory barriers:

The legal and regulatory frameworks for carbon farming varies from region to region. For example, Verra's Verified Carbon Standard (VCS) and Gold Standard are global standards for carbon credit

quantification, However, it is based on the large-scale farming practices observed in the US, while small and marginal farmers with scattered land holdings are more prevalent globally. The complex certification and reporting aggravate the problem further.

5. Equity issues:

The marginalized and small farmers lack land tenure, which makes them reluctant in adopting long term ventures such as carbon farming.

Role of agri-tech in popularising carbon farming

Carbon farming is a data-driven venture which relies on accurate monitoring, data collection, analysis and access. Agri-tech is thus an essential tool for successful carbon farming, as highlighted below.

1. Monitoring and verification:

The tracking of biomass changes, vegetation cover, soil moisture, pH, is possible using numerous tools such as remote sensing, satellite imagery, IoT sensors, and AI. Additionally, it also helps in forecasting the carbon sequestered based on meteorological parameters, and crop type.

2. Farmer training:

To equip farmers with proper awareness and training regarding Carbon farming, agri-tech satrtups can be utilised. Through these customized guidance platforms, knowledge can be disseminated on carbon-positive practices, agro-siliviculture, soil health, etc.

3. Inaccessible carbon markets:

The lack of digital literacy has led to inadequate access to carbon markets. Agri-tech startups can bridge this gap by developing blockchain-based carbon credit registers, aggregating farmers for carbon certification as well as developing carbon market platforms.

4. Data collection:

Since data is the backbone of carbon farming, agri-tech can improve farm digitization by tracking inputs, regular soil health monitoring, carbon-positive practices such as no-till, and forecasting carbon potential based on climate and agronomic practices.

Agri-tech startups associated with carbon farming in India

Currently, India has over 1500 agri-tech startups which are working diligently towards improving the agriculture scenario in our country.

- Agri-tech startups such as **CropIn** provides crop monitoring and satellite based advisory, which can be utilised for tracking carbon sequestration in the farms.
- **DeHaat** farmer app provides frequent advisories, weather reports and crop reminders in vernacular languages, for increasing the digital literacy among the farmers.
- Startup **Digital Green** uses Generative AI to offer climate smart advisories to farmers, resulting in manifold reduction in crop losses.
- **Boomitra** has combined satellite imagery and machine learning to develop a remote sensing methodology for measuring soil organic carbon at scale.
- **Grow Indigo** helps empower small-holder farmers with science-backed monitoring and verification of carbon credits generated. It creates awareness regarding the need and the methods of regenerative agriculture, thus making it simple to register, monitor, verify the good agricultural practices.

Government initiatives and policies

- The Ministry of Agriculture & Farmers Welfare has developed a framework for Voluntary Carbon Market (VCM) in India to incentivize the small and medium farmers through carbon trading mechanism.
- Through its 'National Innovations in Climate Resilient Agriculture' (NICRA) project, the government of India promoted climate resilient agricultural technologies such as intercropping systems, conservation agriculture, crop diversification, agroforestry systems, zero-till sowing, green manuring, etc. which would contribute to carbon positive agricultural practices.
- The government launched Paramparagat Krishi Vikas Yojana to encourage organic farming and improve soil health.

Conclusion

Carbon farming provides dual benefit of alternate incentivisation and climate change mitigation. But incorporating agricultural practices with carbon-positive practices, it helps sequester carbon while improving soil health, water retention as well as farm resilience. In the Indian context, carbon farming, backed by agri-tech innovations, can empower farmers manifold. However, challenges such as lack of awareness, inadequate policy frameworks, and digital literacy needs to be addressed to unlock the full potential of carbon farming.

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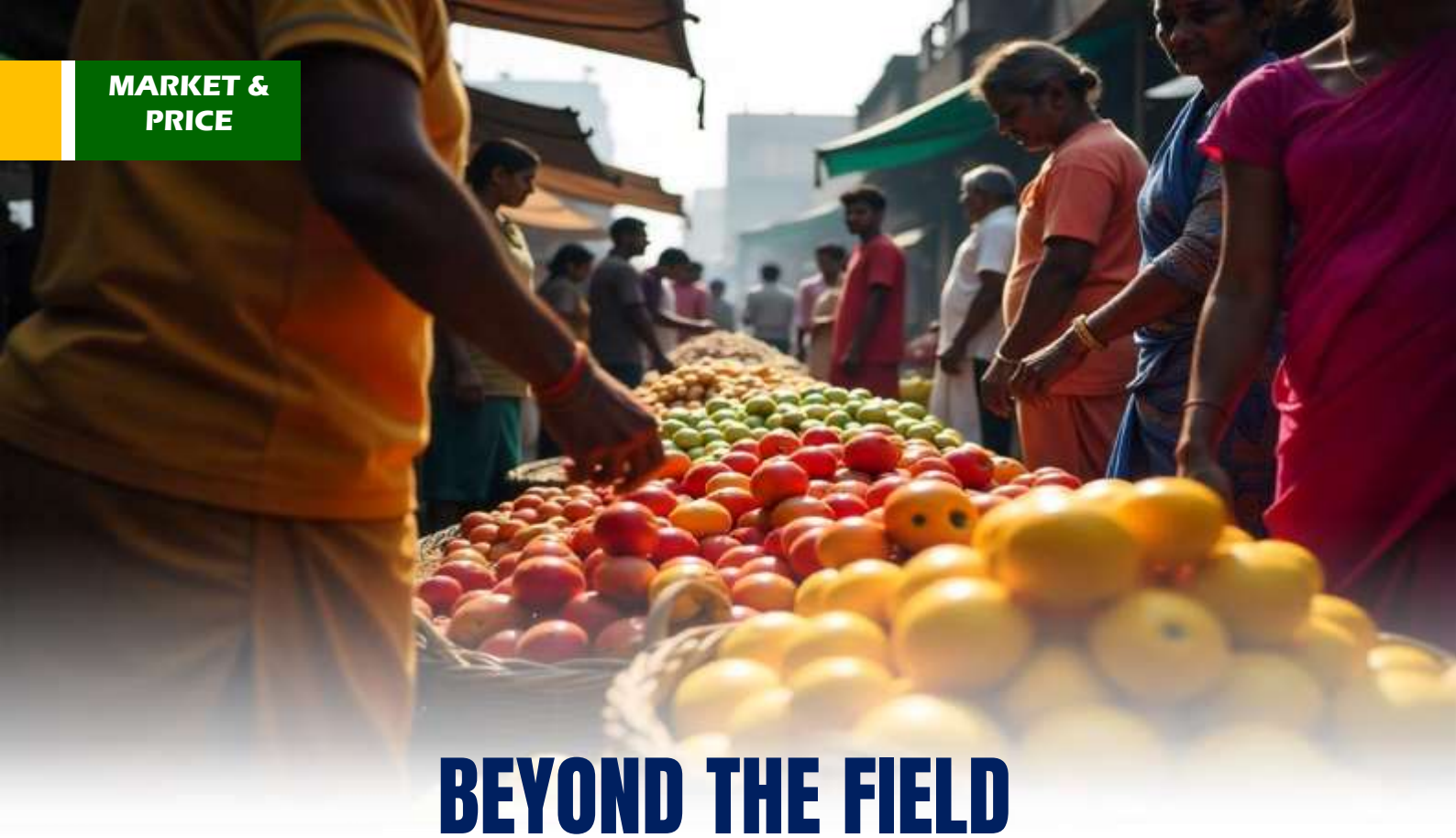

BEYOND THE FIELD

WHY FARMERS NEED BETTER PRICES, NOT JUST BETTER INPUTS

About Author

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Despite decades of investment, India's agricultural sector continues to grapple with one painful truth — farmers remain poor, not because they can't grow crops, but because they can't sell them profitably.

Across the industry, most innovation and investment focus on the input side of agriculture — seeds, fertilizers, pesticides, irrigation tools, or crop advisory services. Startups pitch apps that optimize spraying cycles, drones that monitor soil health, and AI models that predict yield. While these are important, they tackle only one side of the equation. What truly matters is what the farmer takes home after harvest — and here lies the core issue.

Why input-led growth isn't enough?

The logic behind pre-harvest interventions is clear: increase yield, reduce risk, and enhance productivity. But this doesn't automatically translate to higher income. In fact, if the market price crashes, a bumper harvest can often worsen the problem.

A 2023 study by the Centre for Study of Developing Societies (CSDS) and Bharat Krishak Samaj found that more than 70% of small and marginal farmers said their net income decreased or stayed the same, despite using high-cost inputs and modern techniques.

Here's why:

- Prices crash at harvest time due to supply glut.
- Lack of storage or cold chain forces distress sales.
- Middlemen take a large cut, reducing farmer margins.
- Poor access to institutional buyers leads to price suppression.

A Broken output market:

Government interventions like Minimum Support Price (MSP) exist in theory, but only about 6% of Indian farmers actually sell at MSP rates (NSSO, 2019). Most are left to negotiate with local traders, often without weighing scales, receipts, or any bargaining power.

Even platforms like e-NAM (National Agriculture Market), launched to digitize market access, cover only about 1,260 mandis and face operational challenges such as

lack of real-time bidding and poor logistics.

Meanwhile, price volatility due to international markets, climate shocks, and uneven procurement policies makes it hard for farmers to plan financially. This explains why over 50% of farming households are in debt, as per the NABARD All India Rural Financial Inclusion Survey (2018).

The real upliftment: Value realization, not just yield:

The path to real farmer prosperity lies not just in growing more, but in earning more per unit of crop. For this, we need a systemic shift:

- Post-Harvest Infrastructure Invest in warehouses, cold storages, and village-level aggregation centres so that farmers can store and sell when prices are favourable.
- Direct Market Linkages Expand and support platforms like Agri-tech organization that connect farmers to large buyers - retailers, processors, or exporters - removing middlemen and offering better pricing transparency.
- FPO Empowerment Encourage Farmer Producer Organizations to collectively bargain, process, and market produce. States like Maharashtra and Gujarat have shown that successful FPOs improve price realization by 15–25%.
- Price Risk Management Implement price insurance and strengthen mechanisms like PM-AASHA, a price deficiency payment scheme, to protect farmers from price crashes.
- Digital Mandi Networks with Logistics
  Strengthen e-NAM and private mandis with logistics integration, live bidding, and quality grading so farmers get better deals remotely.

Conclusion:

India must stop seeing farmers only as producers and start treating them as agripreneurs- people running small businesses who need market access, fair pricing, and post-harvest infrastructure, not just productivity hacks.

Investing in input technology without fixing output markets is like giving a craftsman better tools but refusing to pay fairly for their finished work.

Until farmers earn more for what they grow, they cannot dream of a better standard of living — no matter how green their fields look.

K-AGTECH LAUNCHPAD

CONVERT YOUR BUSINESS IDEAS INTO AGRI STARTUPS

About Author

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K-AgTech Launchpad

Kerala Agricultural Technology Launchpad (K-AgTech Launchpad) is an advanced incubation center designed to support AgriTech startups, rural entrepreneurs, and farmer-led businesses. The incubator provide opportunity for students, professionals and Youth to convert their business ideas in agriculture to agri startups. With a grant amount of ₹14.57 crore from NABARD, this initiative will provide structured incubation, market linkages, technology access, business acceleration, and women empowerment. The Launchpad provide technological support and technical assistance to the entrepreneurs for establishing their startups.

About the launchpad

Lunchpad is being rolled out under the Rural Business Incubation Centre of NABARD and this initiate stands as the largest- ever NABARD-funded project at Kerala Agricultural University (KAU). The launchpad is setting up at College of Agriculture, Vellayani, Thiruvananthapuram. In this initiative, Kerala Agricultural University (KAU) is collaborating with Western Sydney University (WSU) and the National Bank for Agriculture and Rural Development (NABARD) for supporting start-ups in the farm sector and promoting rural entrepreneurship. This initiate brings together the expertise of KAU, Western Sydney University (WSU), and industry leaders to address key agricultural challenges, foster technological innovation, and transform rural livelihoods. The K-AgTech LaunchPad is not just an incubation centre but a bridge for change, utilizing advanced AgTech solutions to empower farmers, agripreneurs, and rural communities by integrating:

- Incubation support for startups from ideation to market success.
- Value addition and product diversification to boost farmer's income.
- Entrepreneurial capacity building connecting research with industry.
- Al-driven smart climate adaptation technologies to ensure resilience.
- Women-led enterprise empowerment fostering inclusive growth.

The programme was inaugurated on March 14, 2025 at College of Agriculture,Vellayani. The K-AgTech Launchpad is designed to support AgriTech startups, rural entrepreneurs, and farmer-led businesses. The technological support from Western Sydney University (WSU) will boost Agri startups that's been a part of this Incubator.This initiative will catalyze rural business development by supporting individual farmers, FPOs, self-help groups, and other agribusiness collectives, ensuring sustainable growth and competitiveness in agriculture.

The K-AgTech LaunchPad aims to drive economic growth by nurturing start-ups and Ames in the agricultural sector, ensuring climate resilience through smart adaptation strategies, and fostering global collaboration via WSU-led knowledge exchange programs. It will establish a state-of-the-art incubation facility to translate research into real-world impact, promote scalable agripreneurship, value addition, and women empowerment, and create a supportive ecosystem for AI-integrated hi-tech precision agriculture.

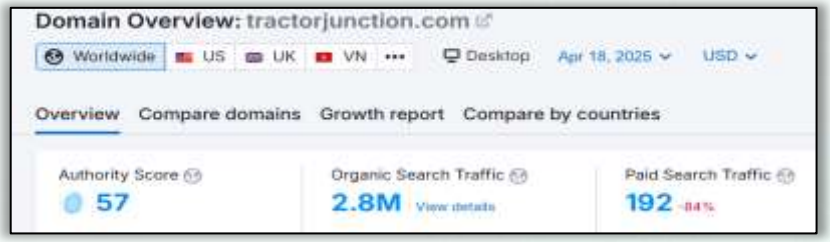
The moto of this initiative is "Empowering Agri Startups,Enabling Climate Resilience and Transforming Rural India". In the logo itself says "Transforming Rural Future" by giving wings to their dreams,making ideas into startups thereby empowering women and individuals to find their own passion.

Through this launchpad students and youngsters in Kerala can benefit by converting their quality business ideas into Agri Startups which ultimately increase employment opportunities and create a growing economy.■

India’s Most Visited Agri-Websites

A quick comparison of the top-performing agriculture websites based on monthly organic search traffic.

Tractor Junction



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