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FLAVORS IN BLOOM

Exploring the World of
Edible Flowers

JULY 2025

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"FLAVORS IN BLOOM:
WHERE PETALS MEET
THE PLATE, TURNING
NATURE'S BEAUTY
INTO A FEAST FOR THE
SENSES."

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from the editor

Nature often surprises us with its beauty—and sometimes, with its taste. In this special edition, *Flavors in Bloom*, we journey through the vibrant and aromatic world of edible flowers—where culinary art meets botanical wonder. Edible flowers have graced tables for centuries, from ancient Roman feasts to modern gourmet cuisine, yet they remain an underexplored realm for many.

This feature delves into the history, cultural relevance, nutritional benefits, and versatile uses of blossoms like nasturtium, marigold, hibiscus, rose, and lavender. With insights from chefs, nutritionists, and horticulturists, we aim to inspire a deeper appreciation for how these delicate petals not only beautify plates but also enhance flavor, texture, and health.

Whether you're a chef, gardener, or curious food lover, this edition invites you to rediscover the garden—this time, as part of your plate. Welcome to a world where beauty is more than skin-deep—where it's also delicious.

Dr. Deepak Kumar
FOUNDER & EDITOR

EXPLORING KNOWLEDGE & DISCOVERING AGRICULTURE



AGRI ROOTS E-MAGAZINE

Flavors in Bloom: Exploring the World of Edible Flowers

ARTICLE ID: 0220

Kamalraj R

M.Sc (Horticulture), Dr.Y.S.R. Horticultural University, COH – Venkataramannagudem, Andhra Pradesh

Edible flowers are gaining widespread attention in culinary, cosmetic and wellness sectors. Historically used in traditional medicine and temple cuisine, flowers are now appreciated not only for their visual appeal but also for their flavor and health benefits. As chefs, nutritionists and food entrepreneurs explore natural, sustainable, and innovative ingredients, edible flowers have

blossomed into a niche yet vibrant component of gastronomy and value-added products.

Common and Culturally Significant Edible Flowers

Edible flowers contribute flavor, color, aroma, and nutrition. Below is an extensive list of both popular and lesser-known edible flowers:

Flower	Flavor	Culinary Use	Health Benefit	Preservation
Nasturtium	Peppery	Salads, pesto	Rich in Vitamin C	Fresh or dried
Rose	Sweet, floral	Desserts, syrups, teas	Mood-lifting, skin-soothing	Dried, crystallized
Hibiscus	Tart, cranberry-like	Teas, jams, sauces	Lowers blood pressure, antioxidant	Dried petals
Marigold	Bitter, spicy	Saffron substitute, soups, rice	Anti-inflammatory	Air-dried
Lavender	Sweet, floral	Baking, teas, aromatherapy	Calming effect	Infused or dried
Pansy	Mild, grassy	Garnishes, cake décor	Rich in anthocyanins	Used fresh
Chamomile	Apple-like	Herbal teas	Sleep aid, digestion support	Dried flowers
Jasmine	Intense floral	Teas, desserts	Relieves anxiety	Infused, dried
Moringa Flower	Mild, earthy	Stir-fries, lentil dishes	Rich in iron and calcium	Cooked fresh

Blue Pea	Mild, earthy	Teas, cocktails, rice coloring	Enhances memory, antioxidant-rich	Dried or fresh
Dandelion	Bitter, nutty	Fritters, teas, salads	Liver detox, diuretic	Dried roots or petals
Safflower	Mild saffron-like	Herbal drinks, rice, soups	Blood circulation, skin health	Dried petals
Lotus	Sweet, starchy	Sweets, temple foods, pickles	Cooling agent, digestion support	Dried or cooked
Banana Blossom	Meaty, nutty	Stir-fries, curries	High in fiber, controls blood sugar	Cooked fresh
Pumpkin Flower	Delicate, squash-like	Stuffed fritters	Rich in beta-carotene	Cooked fresh
Tuberose	Intensely floral	Syrups, liqueurs	Aromatic and calming	Infused or dried
Tulsi Flowers	Peppery, clove-like	Teas, infusions	Immunity booster, antimicrobial	Dried in shade
Coriander Flowers	Citrus-spicy	Garnishes, pickles	Detoxifier, digestive agent	Used fresh
Mint Flowers	Sweet, menthol	Desserts, teas, chutneys	Refreshes breath, relieves nausea	Dried or infused

Nutritional and Medicinal Benefits of Edible Flowers

Edible flowers are not just visual enhancers in cuisine—they are reservoirs of health-promoting phytochemicals. Many flowers traditionally used in

Indian and global cuisines are now backed by scientific evidence for their nutritional and therapeutic value. They offer antioxidants, essential oils, vitamins, minerals and bioactive compounds that support various physiological functions.

Key Bioactive Compounds Found in Edible Flowers

Compound	Function	Found In
Flavonoids	Antioxidant, anti-inflammatory, heart health	Blue pea, rose, marigold, chamomile
Anthocyanins	Anti-aging, improves memory, reduces oxidative stress	Hibiscus, pansy, blue pea
Tannins	Antibacterial, helps in gut health	Hibiscus, dandelion
Essential oils	Calming, antiseptic, antimicrobial	Lavender, jasmine, tulsi

Vitamin C	Boosts immunity, skin regeneration	Nasturtium, hibiscus, rose
Beta-carotene	Precursor of Vitamin A, improves vision and skin health	Pumpkin flower, calendula, safflower
Polyphenols	Reduces inflammation, supports liver health	Dandelion, lotus, tulsi

Therapeutic Highlights of Some Flowers

- **Hibiscus:** Used in Ayurveda and modern herbal medicine to control blood pressure and cholesterol. Also known for its anti-obesity effects.
- **Chamomile:** Has sedative, anti-inflammatory and gastrointestinal calming properties.
- **Blue Pea (*Clitoria ternatea*):** Contains ternatins, anthocyanins known to boost cognition and reduce anxiety.
- **Marigold (Calendula):** Used in wound healing and eye care due to anti-inflammatory properties.
- **Rose:** Rich in antioxidants; aids digestion and reduces stress.
- **Tulsi Flowers:** Immune-boosting, antimicrobial and beneficial for respiratory ailments.

Postharvest Handling and Preservation

Due to their delicate nature, edible flowers require:

- Harvesting early morning for freshness
- Immediate cooling and refrigeration
- Low-temperature drying or freeze-drying
- Vacuum or clamshell packaging to prevent moisture loss

Maintaining hygiene and avoiding pesticide residues is critical for food-grade certification.

Value Addition Possibilities

The versatility of edible flowers offers numerous opportunities for entrepreneurs and farmers:

- Herbal teas & infusions
- Syrups & honey infusions
- Candied petals, floral chocolates
- Floral vinegars & oils
- Skincare products
- Freeze-dried garnishes

Export Potential of Edible Flowers

India's floriculture industry is expanding its footprint in the global edible flower market, driven by demand from health-conscious, gourmet and organic consumers.

Global Market Overview

- Market Value (2022): USD 250 million
- Estimated Value (2027): USD 350 million (CAGR of 5.5%)
- Major Importing Countries: USA, Germany, France, UK, Japan, South Korea

India's Export Performance

Year	Export Quantity (MT)	Export Value (INR Cr)	Top Destinations
2020–21	~310	22.5	UAE, UK, Germany, USA, Qatar
2021–22	~370	27.8	UAE, Japan, USA, Netherlands, Oman
2022–23	~410	31.4	France, USA, South Korea, Singapore

Top Exported Forms

- i) Dried petals (hibiscus, rose, calendula)
- ii) Crystallized rose for confectionery
- iii) Tea blends with blue pea and chamomile
- iv) Infused oils and herbal extracts.

Support: APEDA, PMFME and Mission Organic Value Chain support certification, logistics and branding.

Challenges

- i) Limited awareness of edible-grade standards
- ii) High perishability without cold chain logistics

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- iii) Non-standardized small-scale production

Conclusion

Edible flowers represent an elegant fusion of tradition, nutrition and innovation. With increasing consumer demand for natural, functional and beautiful food, the cultivation and value addition of edible flowers offer a promising opportunity for farmers, florists and food entrepreneurs. By integrating proper postharvest handling, organic practices and creative product development, India can become a global leader in the edible flower value chain.

Carbon Farming: A Sustainable Strategy for Climate Resilience

ARTICLE ID: 0221

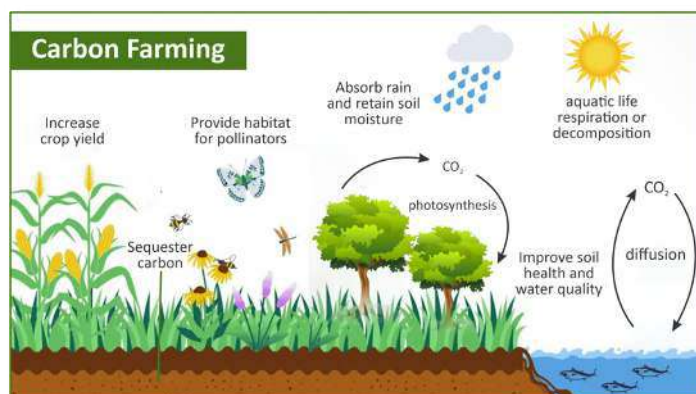
Masoom Ankit Patel

M.Sc. Research Scholar, Department of Seed Science and Technology, Hemvati Nandan Bahuguna Garhwal University, Srinagar (Garhwal), Uttarakhand

As climate change accelerates, agriculture is both a contributor to greenhouse gas (GHG) emissions and a potential solution. "Carbon farming" is emerging as a promising practice that incentivizes farmers to adopt land management strategies aimed at sequestering atmospheric carbon in soil and vegetation. This article explores the concept, techniques, policy implications, and socio-economic challenges of carbon farming, with a specific lens on India's agricultural landscape. Drawing from global literature and national case studies, it evaluates the feasibility and limitations of transforming farmers into frontline climate warriors through climate-smart practices that also generate income from carbon credits. The article emphasizes the need for robust policy support, capacity building, and digital monitoring tools to make carbon farming scalable, measurable, and equitable.

1. Introduction

The relationship between agriculture and climate change is deeply intertwined and multi-dimensional. On one hand, agriculture is a major contributor to greenhouse gas (GHG) emissions through methane released by livestock and flooded rice paddies, and nitrous oxide emissions resulting from synthetic fertilizers. These emissions make up a significant portion of India's and the world's carbon footprint. On the other hand, farming also



presents a unique opportunity often overlooked to combat climate change by turning soils and plants into carbon sinks. This ability to draw carbon dioxide (CO₂) out of the atmosphere and store it in soils and biomass is known as carbon sequestration, a process central to the emerging practice of carbon farming. Carbon farming is increasingly recognized as a nature-based solution that offers dual benefits: it helps mitigate

climate change while also enhancing soil fertility, water retention, and long-term agricultural sustainability. Lal (2020) emphasizes that improving soil organic carbon through sustainable land practices could offset a significant share of global emissions. By adopting practices such as cover cropping, agroforestry, reduced tillage, and organic amendments, farmers can improve soil health while locking away atmospheric carbon. Paustian *et al.* (2016) argue that with proper support, agricultural soils could serve as an effective, low-cost strategy for carbon removal.

2. What is Carbon Farming?

Carbon farming refers to a suite of agricultural techniques that increase the storage of carbon in soil organic matter and biomass (trees, crops, roots). The primary goal is to turn farmland into a carbon sink instead of a carbon source. Key Practices in Carbon Farming includes:

- Agroforestry: Integrating trees and shrubs into croplands or pastures.
- Cover cropping and crop rotation: Enhancing soil carbon by keeping land covered year-round.
- Reduced or no-till farming: Minimizing soil disturbance to protect organic carbon.
- Biochar application: Adding charcoal-like material to soil to stabilize carbon.
- Organic composting and residue retention: Recycling organic waste to boost soil carbon.
- Improved livestock grazing management: Controlling grazing to improve pasture health.

These practices are not only beneficial for the environment but also improve soil fertility, water

retention, and crop yields making them economically attractive in the long run.

3. Scientific Basis and Carbon Sequestration Potential

According to Lal (2004), soil can sequester up to 0.4–1.2 giga-tonnes of carbon annually if sustainable land practices are adopted worldwide. The IPCC's 2019 Special Report on Climate Change and Land also identified soil carbon sequestration as a highly cost-effective mitigation measure. India has around 157 million hectares of arable land and immense potential for restoring degraded soils. A study by Venkatesh *et al.* (2018) found that practices like residue retention and organic inputs could raise soil organic carbon (SOC) stocks by 0.1–0.3 Mg/ha/year. Even a small increase in SOC across India's farmland could lock away millions of tonnes of CO₂ annually. However, measuring carbon sequestration accurately remains a challenge, especially for smallholder farms with diverse cropping patterns.

4. Carbon Credits and the Economics of Carbon Farming

4.1 What are Carbon Credits?

A carbon credit represents 1 tonne of CO₂-equivalent that has been removed from the atmosphere or not emitted. Farmers who implement verified carbon farming practices can earn these credits and sell them on carbon markets.

4.2 Voluntary Carbon Markets (VCMs)

Unlike regulated markets (like the EU Emissions Trading System), VCMs allow private buyers to offset their emissions by purchasing credits from projects such as afforestation, soil management, or renewable

energy. Prices vary widely from \$5 to \$50 per tonne depending on the methodology and co-benefits.

4.3 Revenue Potential for Farmers

Projects in countries like Kenya and Australia have demonstrated successful models like Australia's Emissions Reduction Fund (ERF) provides payments for carbon farming activities. In Kenya, smallholder farmers under the "Soil Carbon Project" earned \$27/ha over 5 years from carbon credits (FAO, 2020). For India, if scaled and verified properly, carbon farming could offer additional income streams, especially for marginal farmers in rain-fed or degraded zones.

5. Indian Initiatives and Case Studies

5.1 National Mission for Sustainable Agriculture (NMSA)

Launched as part of India's broader climate strategy under the National Action Plan on Climate Change (NAPCC), the National Mission for Sustainable Agriculture (NMSA) has been instrumental in encouraging climate-resilient farming. It emphasizes practices like agroforestry, rainwater harvesting, integrated nutrient management, and the distribution of soil health cards to help farmers better understand and improve their soil fertility. These efforts not only promote productivity but also align closely with carbon farming principles by improving soil carbon storage and reducing emissions. In essence, NMSA serves as a government-backed platform that subtly embeds carbon sequestration into everyday agricultural practices.

5.2 Indian Institute of Soil Science (IISS), Bhopal

The Indian Institute of Soil Science (IISS), based in Bhopal, plays a crucial role in making carbon farming

scientifically viable in India. It has created standardized protocols for measuring carbon stocks across different agro-ecological zones in the country. These protocols provide reliable methods for assessing how much carbon is stored in soils under different crops and management systems—an essential step for enabling farmers to earn verified carbon credits. By anchoring scientific research in real-world farm conditions, IISS bridges the gap between agricultural sustainability and climate finance.

5.3 DeHaat and E-Carbon Platforms

Startups like DeHaat and tech platforms like E-Carbon are bringing innovation and digital solutions to the frontlines of Indian agriculture. DeHaat, a fast-growing agri-tech company, is piloting ways to link smallholder farmers with carbon markets through mobile-based services, advisory tools, and input delivery systems. Similarly, E-Carbon is leveraging blockchain technology to ensure transparency and traceability in carbon credit generation. These platforms simplify the process of farmer registration, monitor climate-smart practices through remote sensing, and aim to help farmers—especially smallholders—earn income from carbon sequestration activities without being bogged down by complex paperwork or bureaucracy.

5.4 Organic Farming Model, Sikkim

Sikkim's journey to becoming India's first 100% organic state is a powerful example of how eco-friendly policies can transform agriculture and contribute to climate goals. By eliminating synthetic inputs and encouraging composting, crop rotation, and biodiversity, Sikkim has significantly improved its soil health and boosted soil organic carbon levels. The

state's farming model proves that organic agriculture is not just about health and food quality—it can also be a major contributor to carbon sequestration and emission reduction. Sikkim's success offers both a practical and inspirational blueprint for other states considering climate-smart farming transitions.

6. Challenges in Implementing Carbon Farming in India

Despite its potential, carbon farming in India faces several critical challenges. Measurement, Reporting, and Verification (MRV) of carbon sequestration require scientific tools, satellite data, or soil sampling methods that are often too costly and complex for smallholder farmers. Additionally, the country's highly fragmented landholdings and unclear land tenure systems hinder the implementation of uniform carbon farming practices and aggregation of carbon credits. A major barrier is the widespread lack of awareness and technical knowledge among farmers, highlighting the urgent need to strengthen agricultural extension systems. Equity concerns also arise, as without inclusive policies, only large or well-connected farmers may benefit from carbon markets, leaving smallholders behind. Furthermore, voluntary carbon markets are prone to volatility and credibility issues, with growing worries about corporate greenwashing and the lack of transparency in some crediting mechanisms.

7. Policy Support and Future Directions

To make carbon farming viable in India, a multi-pronged approach is essential. First, providing targeted incentives and subsidies such as through existing schemes like PM-KUSUM and Rashtriya Krishi Vikas

Yojana (RKVY) or a dedicated carbon credit initiative can encourage adoption of low-emission agricultural practices. Second, deploying digital MRV (Measurement, Reporting, and Verification) systems using mobile apps and satellite-based tools will help reduce the cost and complexity of tracking carbon sequestration. Third, promoting farmer aggregation models through Farmer Producer Organizations (FPOs) and cooperatives can enable smallholders to pool resources and carbon credits, lowering transaction costs and enhancing market access. Fourth, fostering public-private partnerships (PPPs) with agri-tech companies and NGOs will be key for scaling up capacity building and developing robust carbon trading platforms. Lastly, implementing carbon literacy programs to educate farmers and extension workers on climate-smart practices, carbon markets, and sustainable land management is critical to ensure inclusive and long-term participation in carbon farming.

8. Conclusion

Carbon farming presents a rare convergence of environmental necessity and economic opportunity. By transforming farms into carbon sinks, we can address climate change while improving livelihoods especially in rural India. However, this transition needs robust institutional frameworks, digital infrastructure, and inclusive financial models. The road ahead requires scientific rigor, social equity, and political will. If done right, farmers could indeed become the frontline climate warriors rewarded not just for what they grow, but for the carbon they store beneath their feet.

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Production Technology For The Cultivation Of Jackfruit

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Dinesh Kumar Meena

Department of Horticulture, School of Agricultural Sciences and Technology Babasaheb Bhimrao Ambedkar
University (A Central University) Vidya Vihar, Raebareli Road, Lucknow- 226025, (UP.), India

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Artocarpus heterophyllus (Syn. Kathal) belonging to family Moraceae is an integral part of common Indian diet and is freely available in Indian and adjoining continents, its medicinal properties are also mentioned in Ayurveda. The plant is reported to possess antibacterial, anti-inflammatory, antidiabetic, antioxidant and immunomodulatory properties. Artocarpus heterophyllus is an important source of compounds like morin, dihydromorin, cynomacurin, artocarpin, isoartocarpin, cyloartocarpin, artocarpesin, oxydihydroartocarpesin, artocarpetin, norartocarpetin, cycloartinone, betulinic acid, artocarpanone and heterophyllol which are useful in fever, boils, wounds, skin diseases, convulsions, diuretic, constipation, ophthalmic disorders and snake bite etc.

The Artocarpus heterophyllus is a species of tree of the mulberry family (Moraceae) is known by

other names jackfruit (Eng.), Kathal, Panas (Hindi), Kanthal (Beng.), Palaa (Tamil), Phanas (Guj & Mar) & Chakka (Malayalam). It is native to Western Ghats of India, Malaysia and also found in central and eastern Africa, south-eastern Asia, the Caribbean, Florida, Brazil, Australia, Puerto Rico and many Pacific Islands (1). It is a large, evergreen tree, 10-15m in height,



indigenous to the evergreen forests at altitude of 450-1,200m and cultivated throughout the hotter parts of India. Stem of this plant is straight rough whereas bark is green or black,

1.25cm thick, exuding milky latex, leaves broad obovate, elliptic, decurrent, glabrous, entire inflorescence solitary axillaries, cauliflorous and ramiflours on short leafy shoots. Male head is sessile or on short peduncles receptacles, sometimes born on the ultimate twing, Female head are oblong ovoid receptacle, syncarpus, cylindrics (2). Seeds are separated horny endocarpus enclosed by sub-

gelatinous exocarpus (1mm thick) oblong ellipsoid in nature. The sweet yellow sheaths around the seeds are about 3–5 mm thick and have a taste similar to that of pineapple, but milder and less juicy Jackfruit (*Artocarpus heterophyllus* Lam) produces heavier yield than any other tree species, and bear the largest known edible fruit (up to 35 kg). The jackfruit tree has several uses. Flakes of ripe fruits are high in nutritive value; every 100 g of ripe flakes contains 287-323 mg potassium, 30.0-73.2 mg calcium and 11-19 g carbohydrates (4). In Bangladesh, it is commonly referred to as “poor man’s food” as it is cheap and plentiful during the season. The nutritious seeds are boiled or roasted and eaten like chestnuts, added to flour for baking, or cooked in dishes. The tree is also known for its durable timber, which ages to an orange or reddish-brown colour, with anti-termite properties (5). The leaves and fruit waste provide valuable fodder for cattle, pigs and goats. Jackfruit wood chips yield a dye, which is used to give the famous orange-red colour to the robes of Buddhist priests. In addition, many parts of the plant, including the bark, roots, leaves and fruits have medicinal properties (6). It requires a soil which is well drained but moist, with a pH. of 4.3 to 8.0 and with medium soil fertility. The optimum temperature is 19 to 29°C, altitude at approx. 1600 meters above sea level and the annual rain fall between 1000 and 2400 mm (7) known as, kathal or kata-hai in Bengali and in Hindi. The Malayalam name chakka was recorded by Hendrik van Rheedee (1678-1703) in the Hortus Malabaricus,

Climatic and Soil Requirements

Jack grows well and gives food yield in warm humid climate of hill slopes and hot humid climate of plains. From sea level up to an elevation of 1200 M jack can be grown successfully. A temperature range of 22-35°C will be ideal. It cannot tolerate frost as well as drought. Under low humidity the bearing is poor and the fruits also do not develop and taste. The West coast plains with high humidity are found

Origin and Distribution of Jackfruit

Jackfruit is a tropical fruit species found in tropical, high rainfall, coastal and humid areas of the world. It belongs to family Moraceae. Scientifically known as *Artocarpus heterophyllus*, it is the favourite fruit of many owing to its sweetness. This family encompasses about 1,000 species in 67 genera, mostly tropical shrubs and trees, but also a few vines and herbs. The word *Artocarpus* is derived from the Greek words *artos* (bread) and *carpos* (fruit). The name “Jackfruit” is derived from the Portuguese *jaca*, which in turn, is derived from the Malayalam language term, *chakka*. The fruit is popularly to be very well suited. Though it tolerates a variety of soils, a deep rich alluvial or open textured loamy soil with slightly acidic condition (pH 6.0 – 6.5) and perfect drainage is ideal

Propagation

Seed: Jackfruit is commonly propagated by seeds. Seed should be sown immediately after extraction since they lose their viability during storage. Soaking seed in NAA (25 mg/L of water) for 24 hrs improve their germination and seedling growth.

Air layering: It is one of the best methods to obtain true to type plant. Air layering of one year-old shoot of

bearing plant gives higher success when treated with IBA (500 ppm)

Epicotyls Grafting: Jackfruit seeds should be sown in poly bags (10cm x 20cm) in the 1st week of July. The seedlings when reached 12-14 cm heights should be used as rootstock for grafting. Scions from the terminal shoot of selected good variety of one season old, having well developed buds should be used. At the base of the individual scion a wedge of 4.0 cm should be prepared and inserted in the split epicotyls region of the stock and tied firmly by polythene strips



Planting: Pits of size 1 cubic meter are dug and filled with top soil mixed with 10 kg FYM. The grafts are planted in the centre of the pits during June-December.

Spacing: Jackfruit is commercially planted at a distance of 8 m X 8 m. Varieties of Jackfruit Several studies including Hossain , Saha , and Jagadees, have reported diversity in jackfruit, based mainly on morphological, phenotypic, and organoleptic characteristics like the size of the tree, structure of the leaf, fruit form, age of fruit bearing, quality of the fruit

flesh, their size, shape, density of spines, colour, texture, odor, quality, and period of maturity . According to Singh and Vinning and Moody, there are at least 30 strains of jackfruit in the Indian subcontinent and 30 more types in Malaysia. In Sri Lanka, several jackfruit cultivars such as 'Vela', 'Varaka (Waraka)', 'Peniwaraka', 'Kuruwaraka', Singapore, or the Ceylon Jack are distributed.

However, there are two main varieties of jackfruit: firm and soft. In the firm variety, the perianth remains firm even at full ripeness, while in the soft variety the perianths become soft and fleshy on ripening. The soft variety has fruits with small, fibrous, soft, and spongy flakes with very sweet carpels, whereas the firm variety is crunchy with crisp carpels and not sweet as the soft variety. The firm variety is considered to be of high quality. Some studies have reported variations in the starch, total sugar, and reducing sugar contents of soft and firm types. Gulabi'(rose scented), 'Champa', Hazari, Rudrakshi, GKVK-1, Swarna. Gumless jack, Muttan Varica, Singapore or Ceylon Jack, Burliar1, Palur-1, Pechiparai-1, Hybrid Jack

Chemical Composition and Nutritional Value

The chemical composition of jackfruit varies depending on the variety. When compared with other tropical fruits jackfruit flesh and seeds contain more protein, calcium, iron, and Thiamine. A study has explored that the ripe jackfruit is richer than apple, apricot, avocado, and banana in some minerals and vitamins.

The caloric content of jackfruit is low, where 100 g of jackfruit only contains 94 calories.

The composition of jackfruit according to the findings of several studies.

Manures and Fertilizers

Apply 80kg of FYM to a tree annually along with chemical fertilizers of 600:300:240g NPK/plant/year for obtaining higher productivity. The fertilizers are applied in split of two doses and applied twice in a year i.e., during June –July and September – October.

Intercropping

Short duration vegetables, leguminous crops cowpea, horse gram, black gram etc. can be grown as intercrop during the first 3 years of planting to obtain more income. After care: Jack trees are trained to a single stem, early side branches should be removed so that a uniform smooth trunk develops for a height of 1.5 – 2 M and then side branches should be permitted to arise. The flower buds appear on trunk which should be kept free of vegetative growth.

Weed Management

Integrated weed management should be encouraged by growing of cover crops, use of herbicides, inter cropping and hand weeding where ever necessary.

Water Management

Usually, Jackfruit is cultivated under rainfed condition. Protective irrigations are necessary initially at 12-15 days intervals depending on soil and climatic condition.

Harvesting and Yield

Jackfruit starts producing fruits from 7th - 8th year onwards in seedling trees. Grafted plants start to yield from 4th - 5th year. Harvest is done during March-July. On an average, Jackfruit yields about 30-40t/ha.

Post Harvest Management

Fruits are stored for 2-3 months at 50C with 85-90% relative humidity and 1 week under room temperature.

Plant Protection Measures Diseases

Fruit Rot: Spraying trees with young fruits using captan (0.2%) or Bordeaux mixture (1.0%) or copper oxy chloride (0.25%) at interval of three weeks during the months of jan-feb & March.



Dieback: Pruning of infected twigs followed by spraying with Carbendazim (0.1%) or Thiophenate methyl (0.2 %) or Chlorothalonil (0.2%) have been recommended.

Phytophthora Fruit Rot: Spraying with Benomyl @ 1g/lit completely controls the disease.



Pests

Brown Weevil: Destroying fallen fruits and buds, collection and destruction of grubs and adults and spraying the trees with monocrotophos (0.035 %).

Shoot And Fruit Borer: Spray monocrotophos 36 WSC 2ml/ litre or carbaryl 50 WP 0.1 %, 4gms or copper oxychloride at 0.25 % to check if there is fruit rot incidence.

Conclusion

Considering the easy availability of *Artocarpus heterophyllus* in our country and that almost all the parts of the plant, including wood & latex possess curative properties, it seems that still there is a scope for scientific studies to fully exploit its medicinal

properties to support the traditional claims as well as, exploring some new and promising 'leads'. This review is an effort to compile all major information on its phytochemical as well as pharmacological profile published till now

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Pushp Rasayan - Utilization of Marigold as Bio-Fertilizer

ARTICLE ID: 0223

Iram Khan

B.Sc. Agriculture Student, Medi-Caps University, Indore, India

Pushp Rasayan is a part of the indigenous technical knowledge (ITK) in agriculture, particularly in the context of organic farming. This method has developed by Tara Chand Balji. It involves the use of Pushp Rasayan as a foliar application to address calcium and boron deficiency. The concept of pushp rasayan - the use of flowers as sources of bio-fertilizers has gained traction as farmers seek eco-friendly alternatives to chemical fertilizers. Marigold offers unique advantages due to its bioactive compounds, compatibility with

beneficial microbes, and positive impact on soil health and crop productivity.

Ingredients for preparing Pushp Rasayan

S.No	Material	Quantity
1	Marigold Flower	1 Kg
2	Cow Urine	1 Liter
3	Water	1 Liter
4	Jar	1 Piece



(a)



(b)



(c)



(d)

Fig. 1.1 (a) Marigold Petals, (b) Cow Urine, (c) Water, (d) Jar

Method for preparing Pushp Rasayan

- Add 1 Kg marigold petals, 1 liter cow urine with 1 liter of water in a jar. Stir the mixture thoroughly.
- Cover the jar with a cloth and tie it properly. This allows air exchange while preventing insects or debris from entering. Place the jar in a shaded location.

- Allow the mixture to ferment for 10-14 days. Continue the twice daily stirring throughout this period.
- After fermentation, the solution is ready for use. For application, dilute 100 ml of the fermented solution in 1 liter of water.

Applications

Soil Drench: Pour the diluted solution around the base of plants to enrich the soil and promote plant health.

Foliar Spray: Use the diluted solution as a foliar spray for enhanced nutrient uptake and pest resistance.

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Benefits

- Provide natural nutrients and beneficial microbes to plants.
- Enhance soil fertility and plant immunity.
- Reduce dependency on chemical fertilizers.

Conclusion

Pushp Rasayan through the strategic utilization of marigold in bio-fertilizer systems—provides a viable pathway for achieving higher yield, improved quality, and sustainable soil management. Adoption of this practice can be recommended for cultivation to maximize both agronomic and ecological benefits.

Trichoderma – A Biocontrol Agent

ARTICLE ID: 0224

Sanchita Gautam

Ph.D. Scholar, Department of Plant Sciences, School of Life Sciences, Central University of Himachal Pradesh, Shahpur, Kangra, Himachal Pradesh, 176206, India

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T*richoderma* spp. are free-living fungi often found in soil and root ecosystems. Known for their ability to control plant pathogens, these fungi suppress diseases through mycoparasitism, competition, and the production of secondary metabolites. Their eco-friendly nature and effectiveness have made them an important part of sustainable agriculture and integrated pest management (IPM) strategies.

Introduction

Agriculture remains as a cornerstone of the Indian economy, yet plant diseases significantly impact crop productivity. While agrochemicals are widely used to combat these diseases, their excessive and non-judicious application poses serious threats to human health and the environment. As an eco-friendly alternative, biocontrol agents like *Trichoderma* have emerged as effective solutions in plant disease management. Naturally occurring in soil microflora, *Trichoderma* species suppress pathogens through

multiple antagonistic mechanisms, contributing to healthier crop ecosystems.

Mode of Action

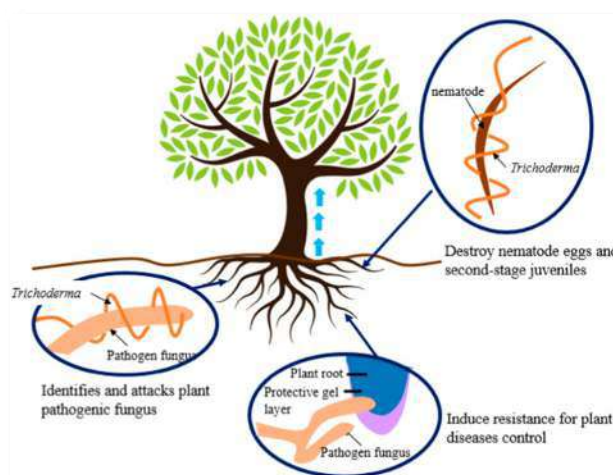
Trichoderma employs several strategies to control phytopathogens:

- **Competition:** It outcompetes pathogens for nutrients and space in the rhizosphere.

- **Enzymatic Degradation:** It secretes hydrolytic enzymes such as chitinases, β -1,6-glucanases, xylanases, proteases, and

mannosidases, which degrade the cell walls of fungal pathogens.

- **Mycoparasitism:** A direct mode of action where *Trichoderma* physically coils around and penetrates the hyphae of pathogenic fungi, leading to their destruction.
- **Induced Resistance:** It can trigger both local and systemic resistance in host plants, enhancing their defense mechanisms against a broad range of pathogens.



These multifaceted actions make *Trichoderma* a robust and reliable biocontrol agent.

Advantages Over Chemical Pesticides

Unlike synthetic fungicides, *Trichoderma* is non-toxic, biodegradable, and safe for beneficial soil microflora. Its various modes of action lower the chances of resistance in pathogens. Moreover, *Trichoderma*-based products are approved for organic farming and leave no harmful residues in soil or crops, making them suitable for long-term agricultural sustainability.

Secondary Metabolite Production

Trichoderma produces a wide array of secondary metabolites (SMs) that contribute to its antagonistic activity:

- **Peptaibols:** Antibiotic peptides that inhibit fungal and bacterial pathogens.
- **Trichodermin:** A trichothecene mycotoxin that impedes the growth of plant-pathogenic fungi.
- **Viridin:** An alkaloid from *T. viride* that suppresses multiple pathogens.
- **Hydrolytic Enzymes:** Including cellulases and chitinases, they break down the structural polymers of pathogen cell walls.

These SMs act as biochemical weapons, reinforcing *Trichoderma*'s biocontrol efficacy.

Smart Formulations for Enhanced Efficacy

Recent advances have led to the development of *cell-free formulations*, also called smart formulations, derived from secondary metabolites produced by *Trichoderma* under controlled conditions. These formulations:

- Enable targeted field applications.

- Are free from live cells, enhancing their shelf life and safety.
- Offer potential applications beyond agriculture, including bioremediation.
- Allow cross-border movement without legislative concerns.

Such innovations significantly reduce dependence on chemical fungicides and broaden the scope of *Trichoderma* usage in integrated disease management.

Applications in Agriculture

- **Seed Treatment:** Enhances germination, vigour, and resistance to seed-borne diseases.
- **Soil Amendment:** Promotes root development and balances soil microflora.
- **Foliar Spray:** Controls foliar pathogens effectively.
- **Compost Additive:** Accelerates composting and suppresses soil-borne diseases.

Challenges and Limitations

Despite its benefits, *Trichoderma* application faces several limitations:

- Efficacy may vary under field conditions due to environmental factors.
- Short shelf life of some formulations.
- Need for crop-specific strain selection.
- Competition with native microbial populations may affect establishment.

Conclusion

Trichoderma spp. are essential biocontrol tools in modern agriculture. Their unique ways of suppressing pathogens, combined with their ability to promote plant growth, make them a sustainable alternative to synthetic pesticides. With ongoing advancements in formulation techniques and strain development,

Trichoderma-based products are likely to become fundamental to sustainable crop protection strategies.

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Use of ICT Tools in Agricultural Extension: Revolutionizing Farmer Outreach

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Battala Sheshagiri¹, Dandyala Supraja²

¹MBA (Agribusiness), Department of Agricultural Economics, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj, Uttar Pradesh, India

²MSc. Vegetable Science, Uttar Banga Krishi Vishwavidyalaya, Cooch Behar, West Bengal, India

Agricultural extension is the cornerstone of transforming agricultural research into practical application on the ground. Traditionally dependent on human agents and face-to-face interactions, extension services have long struggled with challenges such as scale, timeliness, and inclusivity. In India where agriculture supports over 50% of the population reliable and timely extension is essential to improve productivity, adapt to climate variability, and ensure sustainable development.

Information and Communication Technologies (ICTs) are reshaping this dynamic. From radio broadcasts to smartphones and AI-powered apps, ICT tools provide opportunities for more efficient, interactive, and farmer-centric outreach. They bring expert knowledge directly to the fields and mobile devices of even the

most remote farmers, thus bridging the persistent research-extension-farmer gap.

Evolution of ICT in Agricultural Extension

ICT use in agriculture has gone through several distinct phases:



1. Radio and Television Era (1950s–1990s):

Initiatives like *Krishi Darshan* provided generic farm advice on national broadcast platforms. Despite low personalization, this was the first large-scale

information outreach.

2. Telephony and Helpline Phase (1990s–2000s):

The introduction of toll-free farmer helplines and agricultural call centers (e.g., Kisan Call Centres) allowed two-way interaction and real-time problem solving.

3. Internet Portals and Kiosks (2000s):

Web portals such as AGMARKNET and farmer-accessible ICT

kiosks (e-Choupals) offered access to localized information on prices, weather, and schemes.

4. Mobile and Smart App Revolution (2010s onwards): With the rapid spread of smartphones, a wave of mobile applications and SMS-based advisory systems revolutionized communication between farmers and experts.

5. AI, Big Data, and IoT (Emerging Phase): Today, precision farming tools powered by artificial intelligence and the Internet of Things (IoT) offer predictive analytics, automation, and hyper-local advisories.

Major ICT Tools Used in Agricultural Extension

1. Mobile Phones and SMS-Based Services

Mobile penetration in rural India has enabled millions of farmers to access information through voice calls and text messages. Services like mKisan deliver agro-advisories, market prices, and weather updates in regional languages.

Advantages

- Works even on basic phones
- Reaches farmers in remote areas
- Low cost and easy scalability

2. Agri-Apps and Smartphone Services

Mobile apps have become a popular platform for delivering customized and location-specific agricultural information.

Popular Apps

- **IFFCO Kisan App:** Offers weather forecasts, agri-advisories, and mandi prices.
- **Kisan Suvidha:** Government app that connects farmers with input suppliers and crop experts.

- **AgriApp & RML AgTech:** Deliver soil testing advice, pest alerts, and credit linkages.



Picture – Farmer using Agri apps

3. Interactive Voice Response Systems (IVRS)

IVRS allows farmers especially those with limited literacy to listen to pre-recorded advisories or connect directly with extension officers.

Example: Services like *Digital Green*'s voice outreach programs have been successful in tribal and remote belts of Odisha and Bihar.

4. Radio and Community Radio Stations

Community radios remain an accessible and trusted platform in rural areas. These stations broadcast region-specific advisories in local dialects.

Examples:

- Krishi Community Radio Stations (run by Agricultural Universities)
- Radio programs like *Hello Kisan* and *Rythu Mitra*



Picture -Farmer listening to Agriculture radio program in the field

5. Television-Based Extension

TV programs like *Krishi Darshan* and regional language shows continue to serve as important educational tools for millions of farmers.

Impact: Especially popular among older farmers who may not use digital platforms.

6. Digital Portals and Knowledge Hubs

Government and private digital platforms are centralizing agricultural knowledge.

Examples:

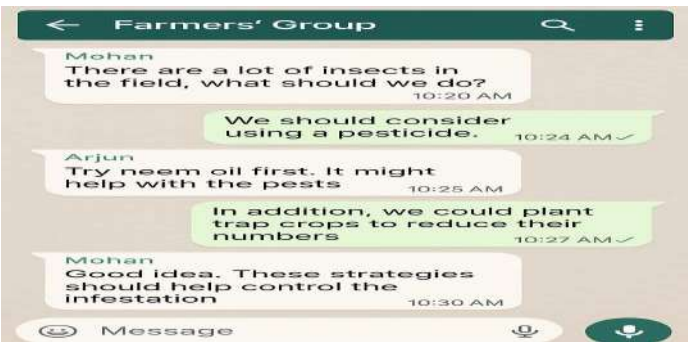
- **e-Choupal (ITC):** Kiosks installed in rural villages for agri-inputs and market access.
- **AGMARKNET:** Real-time mandi price information from thousands of markets.
- **Farmer Portal (Government of India):** A one-stop hub for schemes, advisories, and expert guidance.

7. Social Media Platforms and Messaging Apps

WhatsApp, Facebook, and YouTube are increasingly being used by farmer groups, extension workers, and agripreneurs.

Use Cases:

- WhatsApp groups sharing pest alerts
- YouTube farming channels explaining drip irrigation and organic methods
- Facebook pages for farmer cooperatives



Screenshot of a rural WhatsApp group discussing pest control strategies

8. Artificial Intelligence and Chatbots

AI is powering smart tools that can answer farmers' queries or provide forecasts based on data models.

Example:

- *Microsoft and ICRISAT's AI Sowing App* helped increase crop yields by 30% in Andhra Pradesh.
- *KisanGPT* and other AI chatbots are now being used to deliver interactive advisory in multiple languages.

9. Remote Sensing, GIS, and IoT Devices

These high-tech tools help monitor crop health, soil conditions, and weather, providing data-driven inputs.

Example: CropIn and Fasal use satellite imagery and sensors to deliver precision advisories to farmers.

Government Initiatives Promoting ICT in Agriculture

The Indian government has launched several initiatives to mainstream ICT in agricultural extension:

Program	Focus Area
mKisan Portal	Integrates SMS, IVRS, and expert consultation
Digital India	Promotes rural connectivity and digital literacy
NeGP-A (National e-Governance Plan – Agriculture)	Digitizes extension services across states
Agri Stack (under development)	Will create digital profiles for farmers to provide tailored services

Common Service Centers (CSCs)	Access points for farmers to use digital agri-services
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Benefits of ICT in Agricultural Extension

- **Scalability:** One message or advisory can reach thousands of farmers instantly.
- **Real-Time Updates:** Critical during pest outbreaks or climate events.
- **Cost-Effective:** Reduces the need for physical infrastructure or travel.
- **Customized Advice:** Based on crop, location, soil, and weather conditions.
- **Farmer Empowerment:** Informed decision-making leads to better yield and income.

Challenges in Adoption

Challenge	Impact
Digital Illiteracy	Limits ability to use apps or internet platforms
Language Barriers	Most platforms still lack comprehensive multilingual support
Connectivity Gaps	Internet penetration in some rural areas remains low
Mistrust in Technology	Older generations may resist digital tools
Data Privacy	Concerns about misuse of personal and farm-level data

Case Studies

Case Study 1: e-Choupal (ITC)

Deployed in over 40,000 villages, this digital platform has enhanced access to inputs and markets, reducing dependence on middlemen.

Case Study 2: mKisan SMS Service

Reaches over 5 crore farmers with timely advisories and government scheme updates in local languages.

Case Study 3: Digital Green Videos in Bihar

Localized video content produced and disseminated by rural women led to 25–30% higher adoption of recommended practices.

Future Outlook and Recommendations

- 1. Localization of Content:** Translate and tailor content to local languages and cultures.
- 2. Public-Private Partnerships:** Collaborate with startups and tech companies for innovative solutions.
- 3. Farmer Digital Literacy Campaigns:** Train farmers to use ICT tools effectively.
- 4. Policy for Open Data Access:** Encourage transparency and farmer data rights.
- 5. Focus on Marginalized Groups:** Ensure inclusivity for women, SC/ST farmers, and remote tribal communities.

Conclusion

ICTs have revolutionized the delivery of agricultural extension services by making them more accessible, efficient, and responsive to farmers' needs. From voice-based advisories to AI-driven apps, these tools are helping farmers make smarter decisions, increase productivity, and cope with climatic and market uncertainties.

Despite infrastructural and socio-cultural challenges, the momentum toward digital agriculture is unstoppable. With inclusive planning, sustained investment, and community participation, ICTs will continue to be instrumental in building a smarter, more resilient agricultural system in India.

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Artificial Intelligence in Indian Agriculture: Transforming Crop Management and Enhancing Farmer Livelihoods

ARTICLE ID: 0226

Bishal Dey

Department of Agricultural Extension, Palli Siksha Bhavana(Institute of Agriculture) Visva-Bharati University

Artificial Intelligence (AI) is changing the face of agriculture across the globe, and India—with its varied agro-ecological zones and predominantly small-holder farming systems—could really stand to benefit from this opportunity. Using AI through machine-learning algorithms, computer vision, remote sensing, and IoT devices can make resource management more efficient, forecasting for pest and disease outbreaks, doing the otherwise manual tasks, and improving the supply chain. In essence, this article takes a look back at the development of AI in Indian agriculture, core applications and representative case studies thereof; assesses the opportunities and challenges; and looks toward a future where scaling up AI is done to build a more resilient and rewarding farm enterprise.

1. Evolution of AI in Indian Agriculture

Since the early 2010s, India's public and private sectors have invested in digital agricultural

initiatives—ranging from soil health cards to mobile advisory platforms. However, the integration of AI began in earnest after 2018, fuelled by three converging trends:

- **Data Proliferation:** Satellite imagery, weather station networks, and subsidized smartphones have generated vast agro-climatic and farm-level datasets.



- **Computing Advances:** Cloud-based platforms and edge

computing devices now enable real-time model training and inference, even in rural settings.

- **Policy Support:** The Government of India's Digital Agriculture Mission and initiatives such as eNAM (National Agriculture Market) have created frameworks for data sharing and commercialization of digital solutions.

Early pilots focused on simple decision-support—crop advisories via SMS—evolved into sophisticated AI-driven platforms capable of generating

field-specific recommendations for irrigation scheduling, nutrient management, and market linkages.

2. Key AI Applications in the Field

AI's versatility has yielded a spectrum of use cases across the cropping cycle:

2.1 Precision Crop Monitoring

Computer-vision algorithms, deployed on drones or tractor-mounted cameras, automatically detect foliar diseases, nutrient deficiencies, and weed infestations. For example, convolutional neural networks can classify images of rice paddies with over 90% accuracy for blast disease, triggering targeted fungicide sprays only where needed.

2.2 Yield Prediction and Resource Optimization

Machine-learning models ingest multispectral satellite data (e.g., NDVI time-series), local weather forecasts, and soil maps to predict crop yields at district or even individual-field levels. Accurate forecasts allow cooperatives and agribusinesses to plan procurement, storage, and logistics, reducing post-harvest losses by up to 15%.

2.3 Automated Machinery and Robotics

Robotics start-ups in India are developing AI-enabled robots for tasks such as seeding, weeding, and harvesting. Vision-guided weeders, for instance, use deep learning to distinguish crops from weeds and mechanically uproot the latter, cutting herbicide use by 60%. Automated transplanters and harvesters are still nascent but hold promise for labour-short districts.

2.4 Smart Irrigation and Water Management

AI-powered controllers integrate soil-moisture sensors, local evapotranspiration data, and weather

forecasts to optimize irrigation schedules. Trials in Maharashtra and Karnataka have demonstrated water savings of 20–30% without yield penalties, crucial in water-stressed regions.

2.5 Supply-Chain and Market Intelligence

Natural language processing (NLP) algorithms scrape wholesale market websites to forecast price trends, enabling farmers to decide when and where to sell. Some platforms provide personalized market alerts, helping smallholders capture better margins—an average of ₹200–₹500 extra per metric ton of produce.

3. Illustrative Case Studies

3.1 Fasal: AI-Driven Crop Advisory in Punjab

Fasal, a Bengaluru-based agritech startup, combines IoT weather stations, field sensors, and satellite imagery. Its AI engine delivers crop-specific advisories—on fungicide spray timing or irrigation—to over 200,000 farmers in Punjab. Independent evaluations report a 12% yield increase for wheat and a 15% reduction in input costs within two seasons.

3.2 Microsoft-IARI Partnership on Pest Forecasting

In partnership with the Indian Agricultural Research Institute (IARI), Microsoft's Azure AI Lab developed machine-learning models that predict locust swarm movements and potato blight outbreaks. By integrating real-time satellite imagery with historical outbreak data, the system provides seven-day advance warnings, allowing state agencies to mobilize control measures faster.

3.3 RoboWeed: Autonomous Weeding Robot in Karnataka

A consortium led by a Mysuru university prototyped RoboWeed, a solar-powered, AI-driven weeder. Equipped with stereo cameras and a deep neural network trained on thousands of plant images, RoboWeed operates at 0.8 ha/day, removing 95% of weeds while reducing herbicide use by 70%. Pilot farmers reported 18% higher yields in maize plots.

4. Benefits and Co-Benefits

AI adoption in agriculture generates a cascade of advantages:

- **Increased Productivity:** Precise interventions yield 10–20% yield gains across major cereals and horticultural crops.
- **Cost Savings:** Optimized input use—a fertilizer, pesticides, water—lowers production costs by 15–30%.
- **Environmental Sustainability:** Reduced agrochemical runoff, lower greenhouse-gas emissions from tractors (via smart dispatch), and water-use efficiency contribute to eco-friendly farming.
- **Risk Mitigation:** Early warning systems for pests, diseases, or extreme weather events strengthen climate resilience, reducing crop-failure risk by up to 25%.
- **Empowerment of Smallholders:** Accessible AI services—via voice, regional languages, and low-bandwidth apps—democratize advanced agronomic advice, particularly for marginal farmers.

5. Challenges and Barriers to Scale

Despite these successes, several hurdles impede widespread AI adoption:

- **Digital Divide:** Only 45% of India's farmers currently have reliable internet access in the field, limiting real-time data transmission.
- **Affordability:** High costs of smart sensors, drones, and farm robots remain prohibitive for smallholders without aggregators or cooperatives.
- **Data Quality and Privacy:** Inconsistent data standards across platforms, and concerns over ownership and misuse of farmer data, create trust deficits.
- **Skill Gaps:** Effective use of AI tools requires digital literacy and agronomic understanding; extension services are yet to be fully equipped for such training.
- **Regulatory Ambiguity:** Lack of clear guidelines on AI model validation, liability for mispredictions, and standards for agritech products slows institutional procurement.

6. Policy Recommendations and Enabling Ecosystems

To unlock AI's full potential in Indian agriculture, a multi-pronged approach is necessary:

1. **Infrastructure Investments:** Expand rural broadband and 5G pilots in agri-clusters; subsidize solar-powered IoT nodes.
2. **Subsidy Reforms:** Offer capital-grant support for sensor kits, drones, and AI-enabled machinery, particularly under schemes like FPO strengthening or agri-start-up funds.
3. **Data Trust Frameworks:** Establish public-private data collaboratives with clear data-governance norms, ensuring farmers' rights and incentivizing secure data sharing.

4. Capacity Building: Revamp Krishi Vigyan

Kendras (KVKs) and agricultural universities to include AI-in-agriculture modules and hands-on training.

5. Standardization and Certification: Introduce national standards for agritech products—sensor accuracy, AI-model benchmarks, cybersecurity—to build farmer and institutional trust.

7. Personal Opinion

Artificial intelligence, when applied in agriculture, cannot be a silver bullet for technology because it requires a thoughtful marriage of traditional knowledge and extension support. In my opinion, the greatest gains will come from hybrid models where community-level aggregator services pool resources for AI infrastructure, and local agronomists interpret AI outputs in the cultural and ecological context of the particular area. It remains imperative for policymakers to emphasize decentralization in farmer-owned data platforms and treat incentivizing the co-design of AI tools among its end users as a priority to earn relevance and nurture ownership.

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Conclusion

Using AI technologies in Indian agriculture opens up a range of transformations, from being precise about monitoring the health of crops to testing variations in the machinery and market levels of intelligence. From a more practical perspective, pilots such as Fasal advisory network, the Microsoft-IARI pest forecasts, and RoboWeed's autonomous weeder application have shown improvements to yields, reduction of costs, and positive environmental impacts. However, issues such as digital access, affordability, data governance, and capacity building need to be tackled via policy measures, a collaboration between the private and public sectors, and community engagement. This ecosystem nurtures a balance between state-of-the-art AI and grassroots-level participation, turning India into the stage for the second Green Revolution—a data-driven, resilient, and inclusive one where sustainable livelihoods are guaranteed to millions of smallholders in the coming decades.

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