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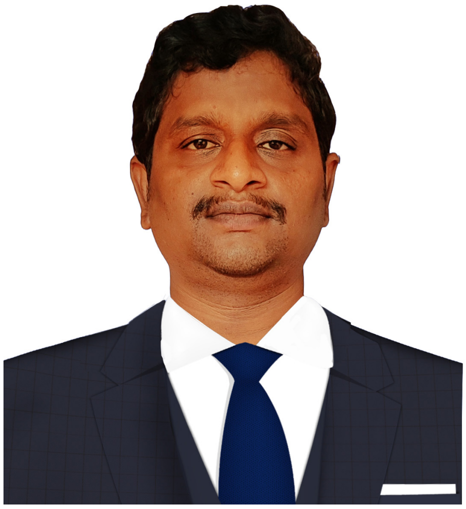
From the Desk of Editor-in-Chief

With immense humbleness and anticipation, I seek it's my pleasure to launch the April 2026 issue of the **"Krishi Netra"** a monthly e-Magazine subtitled "Invisible Vision on Farming" published by **GRN Creatives**. On behalf of the Krishi Netra Editorial Team, I would like to take this opportunity to thank our authors, editors, reviewers and all of them who have volunteered to contribute to the successful release of the first (December) issue of the e-Magazine.



The magazine aims to provide a common platform for the scientific community, research scholars and other readers to publish their ideas, new inventions, research findings etc., to provide the invisible insights for betterment of the farming community. Krishi Netra magazine is primarily focused on the areas of Agriculture, Horticulture, Precision Farming, Fisheries & Animal Sciences, Agriculture Engineering, Agribusiness Management, Food & Dairy Technology, Bio-Sciences/ Life-Sciences, Biotechnology & Biochemistry, Environmental Science &Forestry, Organic Farming, Sericulture and Home Science.

As we turn the pages of Krishi Netra, let us celebrate the unsung heroes, the farmers, the agri-entrepreneurs, the scientists, and the agri scholars. Together, we delve into the realms of sustainable practices, agro ecology, and the transformative power of technology, ensuring that the seeds we sow today yield a bountiful harvest for generations to come.

May this magazine be a source of inspiration, knowledge, and appreciation for the remarkable journey from seed to harvest. Join us on this exploration of the fields that bind us all, as we cultivate a deeper understanding and appreciation for the intricate dance of life on the farm.

I warmly welcome the authors with their contributions that can meet the practical appliances with an integrated/ convergent approach. I wish, with all your support I could see a very bright prospects for Krishi Netra magazine as an eye opener in serving the needs of the farming community.

We look forward for your valuable feedback!
For any questions/ suggestions/ concerns, please contact us: krishinetra@gmail.com
Thank you.

Editor-in-Chief
Gangisetty Srikanth Kumar

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The Unseen Crisis: How Climate Change is Reshaping Seed Development and Threatening Global Food Security

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Abstract

Global food security discussions frequently prioritize crop yield—the total tonnage produced—while often overlooking a critical, microscopic determinant of future harvests: the biological integrity of the seed itself. The seed represents a plant's entire life cycle, from reproduction to germination and the establishment of a new individual. For millennia, the development of seeds has been a finely tuned with nature, guided by predictable seasonal cues of temperature, light, and water. However, as human-induced climate change accelerates, this delicate balance is being thrown into disarray. The escalating frequency and intensity of extreme weather events—heatwaves, droughts, floods—along with rising atmospheric CO2 levels, are profoundly altering the biological, biochemical and genetic processes that govern seed development. This unseen crisis is not merely a threat to crop yields, but represents a fundamental challenge to global food security and the long-term resilience of both agricultural and other plant species.

The Central Role of Temperature: From Maturation to Abortion

Temperature is arguably the most critical environmental factor influencing seed development. Plant life cycles, from flowering (anthesis) to seed filling and maturation, are exquisitely sensitive to thermal conditions. Climate change is disrupting this delicate process in several ways.

Firstly, rising ambient temperatures and the increasing occurrence of heatwaves can accelerate the maturation process. While this might seem beneficial, it often leads to premature seed development. A shortened maturation period can prevent the full accumulation of essential nutritional reserves, such as starches, proteins, and lipids, resulting in smaller, lighter, and less-nutritious seeds (Sanwong *et al.*, 2022). For instance, research has shown that high temperatures during seed development in common beans and annual ryegrass lead to early pod ripening and the production of poor-quality seeds (Siddique and Goodwin, 1980; Steadman *et al.*, 2004). This directly compromises the "100-seed weight," a key commercial trait, and the overall nutritional value of the harvest.

Secondly, and more critically, extreme heat can cause direct physical and physiological damage. Heat stress during the reproductive phase is particularly detrimental, leading to pollen sterility, reduced stigma receptivity, and ultimately, a lower seed set. Studies on crops like wheat, rice, and maize have shown that even short periods of high temperature during flowering and early seed development can lead to a significant reduction in the number of seeds produced and a higher rate of embryo abortion (Chakrabarti *et al.*, 2011). This is often a result of damaged male reproductive components and a disruption of essential biochemical processes, such as the synthesis and accumulation of sucrose and starch in pollen grains (Sita *et al.*, 2017). The combined effect of fewer and lower-quality seeds presents a dual-pronged threat to crop yields and long-term food availability.

Thirdly, the timing of heat stress is paramount. Research has revealed that the vulnerability of seeds to temperature stress is highly dependent on the specific developmental stage. A study on rice found that seed quality was most damaged when brief hot spells coincided with the early stages of seed development. The damage was even more severe when heat stress was combined with drought (Rahman and Ellis, 2019). This highlights a critical, stage-specific vulnerability that

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will become more pronounced with the increasing unpredictability of weather patterns.

The Water Equation: Drought and Flood's Impact : Precipitation patterns are a defining feature of climate, and their disruption is having a significant effect on seed development. Both extremes—drought and flood—present formidable challenges.

Drought stress, especially during the reproductive stage, can lead to a cascade of negative effects. It can cause degeneration of meiocytes, disoriented microspores, and non-viable pollen, all of which contribute to reduced seed formation (Giorno *et al.*, 2013). Water scarcity during the seed-filling stage directly affects the plant's ability to transport nutrients and photosynthates to the developing seed, leading to a reduction in both seed size and number. This is a primary factor behind the estimated 9-10% average yield loss in cereal crops due to drought and heat stress in recent decades (Lesk *et al.*, 2016).

Conversely, extreme rainfall and flooding can also be catastrophic for seed development. While some studies suggest that well-watered conditions can lead to healthier seeds, excessive water can cause soil erosion, seed washout, and damage to the plant. Flooding that submerges the plant, especially later in the maturation process, can cause significant damage to the developing seeds, compromising their quality and viability.

The interaction of temperature and precipitation further complicates the picture. Seeds from plants that develop under both cool temperatures and reduced moisture conditions have been found to lose dormancy faster than seeds from well-watered plants, highlighting the complex interplay of these environmental factors (Steadman *et al.*, 2004).

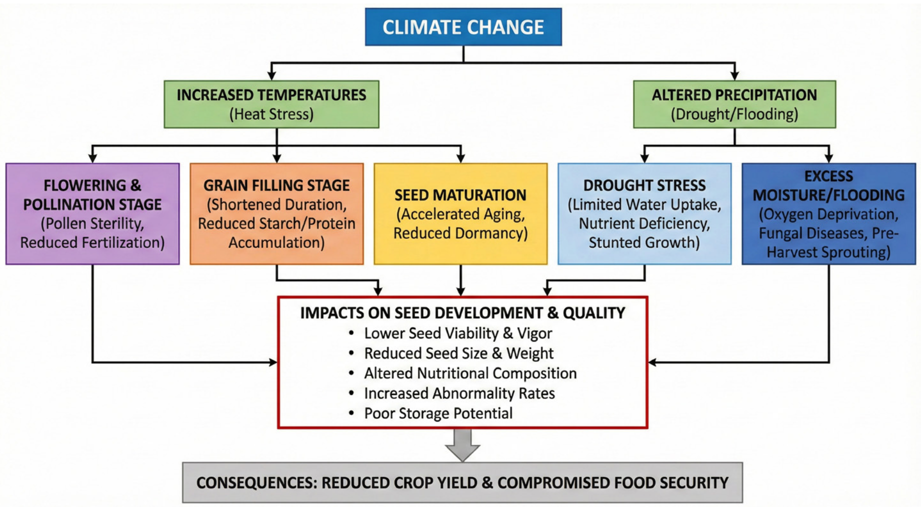

Fig. Temperature and Water affecting seed development and vigour

The CO_2 Paradox: A Double-Edged Sword

Rising atmospheric CO_2 concentrations are a primary driver of climate change, and their effect on seed development is a subject of ongoing research. The relationship is complex, often described as a paradox with both positive and negative outcomes.

On one hand, elevated CO_2 can act as a fertilizer, increasing the rate of photosynthesis and boosting plant growth and yields in many C_3 plants. This "CO_2 fertilization effect" can lead to a greater number of flowers, fruits, and seeds, as well as an increase in individual seed mass (Jablonski *et al.*, 2002). This effect is particularly pronounced in legumes, which can use the increased carbon gain to enhance nitrogen fixation, thereby increasing seed mass without a corresponding decrease in nitrogen content.

However, the benefits of increased CO_2 often come at a significant cost to seed quality. Studies have consistently shown

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that elevated CO_2 can lead to a reduction in the protein and nutrient content of seeds, particularly in non-legumes. This is due to a change in the carbon-to-nitrogen (C/N) ratio, as plants accumulate more carbon from the atmosphere but cannot acquire enough nitrogen from the soil to maintain the same nutritional balance (Hikosaka *et al.*, 2011). A reduction in seed protein content can compromise seed viability and the ability of the seed to support the de-novo protein synthesis necessary for the initial growth of the embryo. This is a critical concern for global nutrition, as staple crops like wheat and rice, which are the primary sources of protein for many populations, are particularly vulnerable to this effect.

Implications for Seed Dormancy and Germination

Seed dormancy is an adaptive trait that prevents germination during unfavourable conditions. Climate change is directly interfering with this process. Seeds that require moist cold conditions for dormancy break, often found in cold/boreal climates, are particularly vulnerable. A reduction in the period of favourable cold conditions due to warming might lead to a lower degree of dormancy breaking, potentially affecting natural plant regeneration (Rosbakh *et al.*, 2023).

Conversely, shifts in temperature and rainfall can alter the timing of germination for non-dormant seeds. If temperatures are favourable but the wet season is delayed, the timing of germination can be shifted, which could expose vulnerable seedlings to subsequent adverse conditions. This can disrupt competitive dynamics in ecosystems, favouring some species over others and altering community composition.

The Epigenetic Inheritance and Adaptive Strategies

Plants are not passive victims of climate change; they possess complex mechanisms to respond and adapt. One fascinating area of recent research is the concept of "epigenetic inheritance." This refers to changes in gene expression that are not caused by alterations in the DNA sequence itself but can be passed down to the next generation. A recent study highlights the potential for "maternal environmental effects," where the conditions a mother plant experiences during seed development—such as heat, cold, or drought—can influence the traits of the resulting seeds and seedlings (Leprince *et al.*, 2016). This can lead to a type of "climate-smart seed" that is better prepared to handle future stresses.

For instance, high temperatures during seed maturation can promote seed germination vigour, while lower temperatures tend to increase the dormancy level. Understanding and harnessing these epigenetic mechanisms could be a crucial strategy for developing crops with enhanced resilience.

Conclusion: A Call for Urgent Action and Innovation

The effect of climate change on seed development is a complex and multifaceted problem with profound implications for both natural ecosystems and human civilization. The latest research paints a picture of a system under immense stress, where rising temperatures, altered precipitation patterns, and increasing CO_2 levels are compromising seed quality, reducing yields, and threatening the long-term viability of plant populations.

Addressing this challenge requires a multi-pronged approach. First, there is an urgent need for more research, particularly in underexplored areas like tropical biomes and southern latitudes, to better understand the diverse and often species-specific responses to climate stress. Second, agricultural innovation is paramount. Plant breeders focusing on developing new crop varieties that are not only high-yielding but also thermotolerant, drought-resistant, and capable of maintaining nutritional quality under climate stress holds utmost importance. Genetic breeding for traits like improved water-use efficiency and enhanced resistance to pests and diseases, whose ranges are also shifting with the climate, will be critical.

Finally, effective climate change mitigation and adaptation strategies are essential. Farmers and agronomists will need to adopt new practices, such as selecting heat-tolerant varieties, optimizing sowing times, and improving soil water management to build resilience. The fate of our future food supply is intrinsically linked to the health and vitality of the

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seeds we plant. As the climate changes, ensuring that the seeds we sow are not just viable but resilient will be a defining challenge of the 21st century, in which, the ongoing researches and other mitigation measures applied will act as pillars for future food security.

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Utilization of Medicinal and Aromatic Plants (MAPs) waste for bio-enriched compost

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Abstract

Medicinal and aromatic plants (MAPs) are cultivated for valuable bioactive compounds used in herbal medicines, nutraceuticals, and essential oil industries. Important examples include withanolides from Ashwagandha, saponins from Safed Musli and essential oils from Tulsi, Lemongrass, Palmarosa, Kali Haldi, and Vetiver. Industrial processing of these plants for extraction of essential oils and other secondary metabolites generates large quantities of residual biomass. This waste is often discarded despite its high organic matter and nutrient content, posing environmental challenges. Aromatic plant residues are rich in lignocellulosic components such as cellulose (35–40%), hemicellulose (25–30%), and lignin (15–20%), making them suitable for organic recycling. A sustainable waste to wealth approach involves converting MAP processing residues into nutrient rich compost through microbial-mediated decomposition. The composting process utilizes MAP waste (100 kg) supplemented with cow dung (10%), urea (1%), diammonium phosphate (DAP, 10%), and microbial consortia (1%). Maintaining an optimal carbon-to-nitrogen ratio of 25–30:1 and moisture content of 50–60%, along with periodic turning, ensures efficient microbial activity. Beneficial microorganisms such as *Trichoderma, Bacillus, Phanerochaete*, and *Actinobacteria* accelerate lignocellulosic degradation. Compost maturation occurs within 90-120 days, producing stabilized organic manure that improves soil health and supports sustainable MAP cultivation systems.

Key words: Aromatic, Waste, Decomposition, Bioagents, Biomass

Introduction : Medicinal and aromatic plants (MAPs) are essential for human health and disease management. Traditionally, these species were naturally present in forests and wild ecosystems, where they were collected by tribal and rural communities for subsistence and income. Increasing commercial demand and unregulated overexploitation have exerted significant pressure on natural populations, resulting in the depletion or near extinction of several key MAP species. Field residues, such as leaves, stems, flowers, and roots, remain after harvesting. Consequently, systematic conservation, scientific cultivation, and sustainable utilization of MAPs are critically important. Organized cultivation not only preserves natural biodiversity but also ensures a consistent and reliable supply of raw materials for the food, pharmaceutical, cosmetic, and nutraceutical industries. This strategy supports environmental conservation, enhances rural livelihoods, and promotes the long-term sustainability of MAP-based industries.

The increasing demand for medicinal plants has led to the generation of substantial biomass waste, typically discarded as a byproduct following hydro distillation. This waste constitutes an underutilized resource that can be leveraged to address critical agricultural and environmental challenges, such as enhancing soil health

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through biofortified compost and reducing plastic waste by developing sustainable packaging materials. This concept note proposes the utilization of medicinal plant waste within a circular economy framework, emphasizing the viability and commercial potential of mushroom cultivation using waste plant material. The cultivation and processing of medicinal plants produce considerable organic waste, including leaves, stems, roots, bark, extraction residues, and post-harvest remains. Traditionally, this waste was often incinerated, dumped, or left to decompose, resulting in pollution, nutrient depletion, and greenhouse gas emissions. With the increasing emphasis on sustainable agriculture and the circular bioeconomy, composting medicinal plant waste is now recognized as an environmentally friendly and cost-effective strategy for waste management and soil improvement. These plant residues are rich in organic carbon, essential nutrients, and diverse bioactive compounds. When properly composted, they can be transformed into high-quality organic manure that enhances soil fertility, stimulates microbial activity, and supports the continued production of medicinal plants.

Waste material generated from MAPs : Medicinal and aromatic plants (MAPs) are cultivated primarily for their pharmaceutically valuable bioactive constituents. Examples include withanolides and withaferin from *Ashwagandha* (*Withania somnifera*), saponins from *Safed Musli* (*Chlorophytum borivilianum*), and essential oils from *Tulsi* (*Ocimum sanctum*), *Lemongrass* (*Cymbopogon flexuosus*), *Palmarosa* (*Cymbopogon martinii*), *Mentha* species, and *Kali Haldi* (*Curcuma caesia*) and *Vetiver* (*Chrysopogon zizanioides*). Industrial processing of these plants generates substantial quantities of biomass following the extraction of essential oils, alkaloids, phenolics, and other secondary metabolites. This residual biomass, known as processing waste, is often discarded or underutilized despite its high organic matter and nutrient content. Effective management and utilization of this waste are critical for promoting sustainable production systems and protecting the environment. Aromatic waste biomass contains cellulose (35–40%), hemicellulose (25–30%), and lignin (15–20%) in large quantities.

The herbal and pharmaceutical industries utilize different parts of medicinal and aromatic plants for the extraction of bioactive compounds. The roots of Ashwagandha, Safed Musli, and Vetiver are used to extract therapeutically important constituents. The leaves of Lemongrass, Palmarosa, Ocimum spp., and Kali Haldi are used for the extraction of essential oils. The stems of Tulsi, *Hibiscus sabdariffa*, and *Isabgol* (*Plantago ovata*) are also utilized after the recovery of industrially important compounds.

Composting Process Ingredients for composting

MAPs, waste-100 kg, Cow Dung 10 kg (10%), Urea -1Kg (1%), DAP-10kg (10%), Microbial consortia 1 kg (1%)

Waste residues produced from the distillation of aromatic plants are collected and shredded to increase the surface area available for microbial activity. Elevated carbon-to-nitrogen (C/N) ratios can prolong the composting period, whereas low C/N ratios may lead to greater nitrogen loss. Bulking agents, such as cow dung or soil, are incorporated to adjust the C/N ratio to an optimal range of 25–30:1, facilitating rapid nitrogen release for crop uptake. When the C/N ratio exceeds 35, microbial immobilization occurs. The substrate is inoculated with composting microbial consortia, including cellulolytic, lignolytic, and nutrient-solubilizing

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microorganisms (Fig.1).Moisture content is maintained at 50–60%, and periodic turning ensures adequate aeration and uniform decomposition. Compost maturation typically requires 45–90 days, depending on temperature, substrate characteristics, and microbial activity, resulting in stabilized, nutrient-rich organic compost. Figure 2 illustrates the composting process. Microbial inoculants, such as *Trichoderma*, *Bacillus*, *Phanaerochaete, and Actinobacteria, are introduc*ed to accelerate decomposition and enhance compost quality.

Fig. 1. Microbial inoculants used for the degradation of waste biomass.

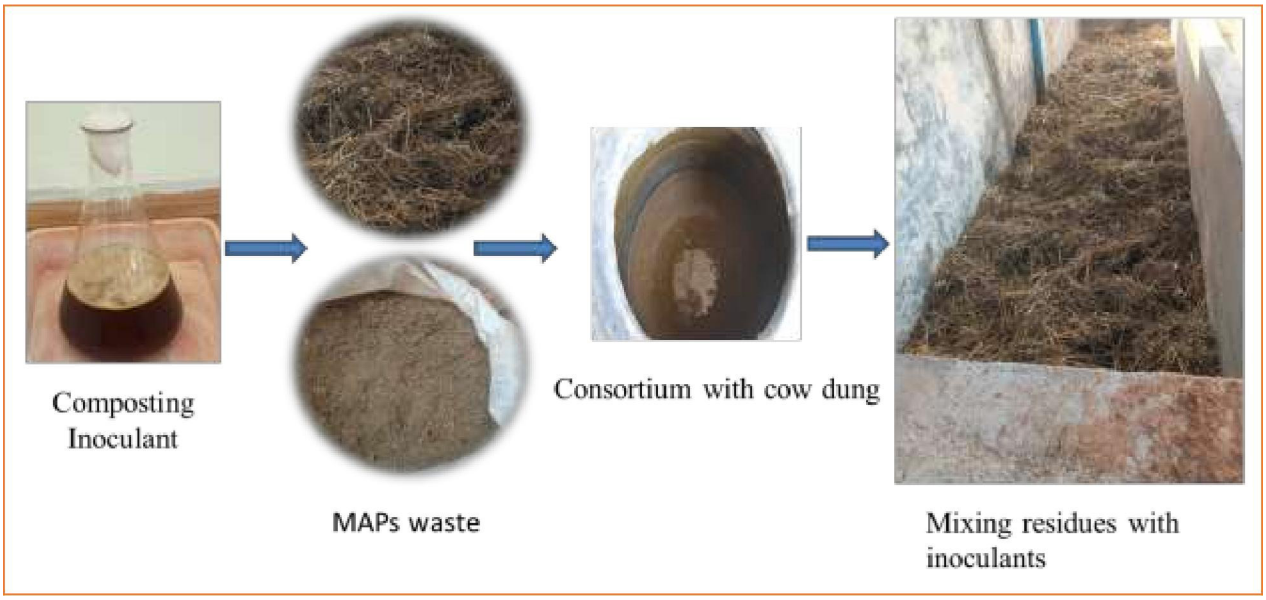

Fig. 2. Bio-enriched compost process from MAPs

Benefits of Using Medicinal Plant Waste Compost

- It helps improve soil structure, increases porosity, and allows the soil to hold more water.
- It enhances soil microbial diversity and increases enzymatic activity.
- It provides slow-release nutrients, including nitrogen, phosphorus, potassium, and essential micronutrients.

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- It can help control some soil-borne diseases due to its residual bioactive compounds.
- It reduces the need for chemical fertilizers and can help lower production costs.
- It supports organic and natural farming methods.

Conclusion

Composting is a sustainable method that converts industrial and agricultural waste into valuable organic inputs for medicinal plants. It reduces environmental pollution, increases crop productivity, improves soil health, and supports the circular bioeconomy in the production of medicinal plants. Composting is consistent with organic and natural agricultural principles and promotes long-term sustainability in medicinal plant farming systems.

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Climate Smart Village

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ABSTRACT

Climate change has become one of the biggest challenges affecting agriculture and rural livelihoods across the world. Rising temperatures, unpredictable rainfall, droughts, and floods are making farming more difficult, especially for small and marginal farmers. The concept of the Climate-Smart Village (CSV) was introduced to help rural communities adapt to climate change while improving agricultural productivity and protecting the environment. A Climate-Smart Village integrates climate-smart agriculture practices, renewable energy, water conservation, and community participation to build resilience against climate risks. This article discusses the meaning, objectives, key features, benefits, and importance of Climate-Smart Villages in creating a sustainable and secure future for rural areas.

Introduction

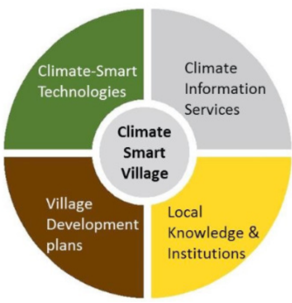
Villages are the backbone of many developing countries, as a large part of the population depends on agriculture for their livelihood. However, climate change has started to seriously affect rural life. Farmers face crop failures, water shortages, soil degradation, and increasing costs of cultivation. Traditional farming methods are often no longer enough to deal with these challenges.

To address this problem, scientists and development organizations introduced the idea of Climate-Smart Villages. A Climate-Smart Village is not just about farming techniques; it is a holistic approach that combines agriculture, natural resource management, technology, and community involvement. The goal is to help villages become more resilient, productive, and environmentally friendly in the face of climate change.

What is a Climate-Smart Village?

A Climate-Smart Village is a rural community that adopts climate-smart agriculture (CSA) practices and sustainable development strategies to:

- Increase agricultural productivity
- Adapt to climate change
- Reduce greenhouse gas emissions where possible



https://www.researchgate.net/figure/Components-of-Climate-Smart-Village_fig1_291096264

The concept was promoted by organizations such as the CGIAR to test and demonstrate practical solutions that farmers can easily adopt.

Key Features of Climate-Smart Villages

- Climate-Smart Agriculture Practices

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- Use of drought-tolerant and climate-resilient crop varieties
- Crop diversification and mixed farming
- Improved soil management, such as mulching and organic farming
- Efficient Water Management
- Rainwater harvesting
- Drip and sprinkler irrigation systems
- Construction of farm ponds and check dams
- Renewable Energy Use
- Solar pumps for irrigation
- Biogas plants for cooking
- Solar lighting in households and streets
- Weather and Climate Information Services
- Access to weather forecasts
- Agro-advisory services through mobile phones
- Early warning systems for extreme weather events
- Community Participation and Capacity Building
- Training farmers and villagers
- Involvement of women and youth
- Strengthening local institutions and self-help groups

Benefits of Climate-Smart Villages

- Improved crop yields and farm income
- Reduced risk from droughts, floods, and heat stress
- Better use of natural resources like water and soil
- Lower dependence on fossil fuels
- Improved food security and livelihoods
- Increased awareness and preparedness for climate change

Smart Use of Water: Every Drop Matters

Water scarcity is one of the biggest problems villages face today. Climate-Smart Villages treat water as a precious resource.

- **Rainwater harvesting** collects water from rooftops and stores it for later use.

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- **Drip and sprinkler irrigation** ensure water reaches plant roots directly, reducing waste.
- Ponds and check dams help **recharge groundwater**.

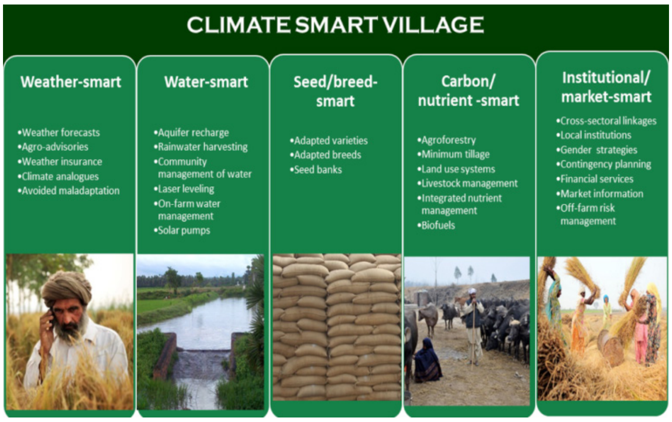
Women, who earlier walked long distances to fetch water, now have easier access. This saves time, improves health, and allows girls to attend school regularly.

Clean Energy for a Cleaner Future

In a Climate-Smart Village, energy does not come only from firewood or fossil fuels.

- **Solar panels** power homes, schools, and streetlights.
- **Biogas plants** convert animal waste into cooking gas.
- Energy-efficient stoves reduce smoke inside homes, improving health.

These changes reduce pollution and protect forests while making daily life easier and safer.



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Community at the Heart of Change

What truly makes a Climate-Smart Village successful is **people's participation**. Farmers, women, youth, and elders all play a role.

Village meetings are held to:

Share knowledge about weather forecasts

- Plan cropping patterns together
- Manage shared resources like water and forests

Women's self-help groups often lead initiatives such as kitchen gardens, seed banks, and small enterprises. Young people learn new skills and help spread awareness using technology.

Protecting Nature While Living With It

Climate-Smart Villages understand that humans are part of nature, not separate from it.

- Trees are planted to prevent soil erosion and provide shade

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- Local biodiversity is protected.
- Waste is reduced, reused, and recycled.

Healthy soil, clean water, and green landscapes ensure long-term survival for future generations.

Importance of Climate-Smart Villages

Climate-Smart Villages serve as model villages that show how rural communities can survive and grow despite climate challenges. They encourage innovation, promote sustainable living, and empower farmers with knowledge and tools. By adopting climate-smart practices, villages can protect both present and future generations.

Conclusion

Climate change is a reality that cannot be ignored, especially in rural areas where livelihoods depend heavily on nature. Climate-Smart Villages offer a practical and hopeful solution by combining traditional knowledge with modern technology. They help farmers adapt to changing climatic conditions, improve productivity, and protect the environment. By promoting sustainable agriculture, efficient resource use, and community involvement, Climate-Smart Villages play a crucial role in building resilient and self-reliant rural communities. Expanding this approach can lead to a more sustainable and climate-resilient future for villages across the world.

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Digital Soil Mapping as a Tool for Enhancing Nutrient Use Efficiency

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Abstract

Digital Soil Mapping (DSM) shifts agriculture from point-based sampling to high-resolution spatial modeling, integrating the SCORPAN framework with machine learning (e.g., Random Forest) to predict soil nutrient variability.

The shift to Site-Specific Nutrient Management (SSNM) uses GPS-based Variable Rate Technology and 4R principles to enable precise fertilizer application tailored to soil variability, improving nutrient use efficiency, reducing environmental losses, and enhancing crop yields.

The study highlights global initiatives (2024–2026) supporting DSM as a “digital twin” for land management, emphasizing its shift from a research tool to a foundational technology for sustainable, data-driven agriculture and global food security.

Key words: Digital Soil Mapping (DSM), Site-Specific Nutrient Management (SSNM), Variable Rate Technology (VRT), Nutrient Use Efficiency (NUE)

Introduction

Digital Soil Mapping (DSM) is the creation and population of spatial soil information systems through the use of numerical models that infer the spatial and temporal variation of soil properties from soil observations and environmental variables (McBratney *et al*., 2003). Unlike traditional mapping, which often relies on subjective, manual surveys with low spatial resolution, DSM utilizes quantitative techniques to predict soil characteristics at unvisited locations (Minasny & McBratney, 2016; Reddy *et al*., 2024).

In the context of nutrient management, DSM serves as the foundational “blueprint” for precision agriculture (Reddy *et al*., 2024). By integrating high-resolution data from satellites, drones, and proximal sensors, DSM allows for the identification of nutrient deficiencies and spatial variability within a single field (Dharumarajan *et al*., 2022). This technology facilitates Site-Specific Nutrient Management (SSNM), enabling farmers to transition from uniform fertilizer applications to “targeted input decisions” that match the specific needs of different soil zones (Dharumarajan *et al*., 2022; Reddy *et al*., 2024).

Soil is far more than just a medium to hold plants upright; it is a dynamic biological and chemical engine that dictates the quantity and quality of our food. Understanding how soil governs crop nutrition involves looking at its physical structure, chemical exchange, and the living ecosystem within it.

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1. The Reservoir of Essential Nutrients

Soil acts as a massive storage tank for the 17 essential elements plants need to grow. These are generally categorized by the quantity required:

- **Macronutrients:** Nitrogen (N), Phosphorus (P), and Potassium (K) are the "big three" required for structural growth and energy transfer.
- **Secondary Nutrients:** Calcium, Magnesium, and Sulfur.
- **Micronutrients:** Elements like Zinc, Iron, and Manganese, which, despite being needed in tiny amounts, are critical for enzyme activation and photosynthesis.

2. Cation Exchange Capacity (CEC)

One of the most vital functions of soil is its ability to hold and release nutrients. Most plant nutrients are positively charged ions (cations). Soil particles—specifically clay and organic matter—are negatively charged.

- **The Magnet Effect:** Like a magnet, the soil holds onto these nutrients, preventing them from washing away (leaching) during rain.
- **Bioavailability:** When a plant needs nutrients, it exchanges hydrogen ions for the nutrients held on the soil particles, pulling them into the roots.

3. pH: The "Gatekeeper" of Nutrition

The acidity or alkalinity of the soil (pH) determines whether a nutrient is actually "available" to the plant. Even if a soil is rich in Phosphorus, a pH that is too low (acidic) or too high (alkaline) can cause the Phosphorus to chemically "lock-up," making it impossible for the roots to absorb it. Most crops thrive in a slightly acidic to neutral range (pH 6.0 to 7.0), where nutrient availability is maximized.

4. The Role of Soil Organic Matter (SOM)

Organic matter—decayed plant and animal material—is the "black gold" of crop nutrition.

- **Slow-Release Fertilizer:** As microbes break down organic matter, they release nutrients in a form plant can use.
- **Structure:** Organic matter improves soil "tilth," allowing roots to penetrate deeper and access a larger volume of soil and water.

5. The Living Soil (Microbiome)

A healthy soil is teeming with life, from bacteria to fungi, which play specific roles in nutrition:

- **Nitrogen Fixation:** Certain bacteria (like *Rhizobium*) live in root nodules and "fix" atmospheric nitrogen into a form the plant can eat.
- **Mycorrhizal Fungi:** These fungi form symbiotic relationships with roots, effectively extending the root system's reach to find water and phosphorus in tight soil pores.

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Precision in Management

Because soil is naturally variable across a single field, modern agriculture often uses **Digital Soil Mapping (DSM)** and **Spatial Analysis** to understand these nutrient gradients. By mapping things like pH, CEC, and organic matter levels, farmers can apply fertilizers precisely where they are needed rather than using a "one size fits all" approach.

From Traditional Soil Testing to Digital Mapping

The evolution from traditional soil testing to digital mapping represents a shift from localized, point-based snapshots to a continuous, high-resolution understanding of the landscape. While traditional methods rely on physical sampling and laboratory analysis to provide a mean nutrient value for a specific area, **Digital Soil Mapping (DSM)** utilizes secondary data—such as satellite imagery, topographic relief, and proximal sensors—to predict soil properties across every square inch of a field. By applying mathematical models like **Random Forest** to these datasets, practitioners can move beyond "flat" averages to visualize spatial variability, allowing for the precise management of nutrients and the optimization of crop yields based on the unique chemical and physical signature of the soil at any given coordinate.

How Soil Digital Mapping Works

Digital Soil Mapping (DSM) operates as a data-driven framework that predicts soil properties across a landscape by combining field observations with environmental covariates. Instead of relying solely on physical samples, DSM uses the **SCORPAN** model, which integrates factors such as climate, organisms, topography, parent material, and age, often captured through satellite imagery and Digital Elevation Models (DEMs). These diverse datasets are fed into machine learning algorithms—most commonly **Random Forest** or **Boosted Regression Trees**—to find statistical correlations between the environmental predictors and measured soil data. The result is a high-resolution, continuous raster map that visualizes spatial variability, allowing for a precise understanding of nutrient distribution and soil health at every coordinate in a field.

Key Components of the DSM Framework

The most widely adopted framework for DSM is the scorpan model, which views soil properties (S) as a function of seven environmental factors (McBratney et al., 2003):

$$S = f(s, c, o, r, p, a, n) + e$$

- s: Legacy soil properties.
- c: Climate (e.g., precipitation affecting nutrient leaching).
- o: Organisms/Vegetation (e.g., NDVI indices from remote sensing).
- r: Relief/Topography (e.g., slope affecting runoff).
- p: Parent material (e.g., underlying geology).
- a: Age (e.g., soil development time).
- n: Spatial position.

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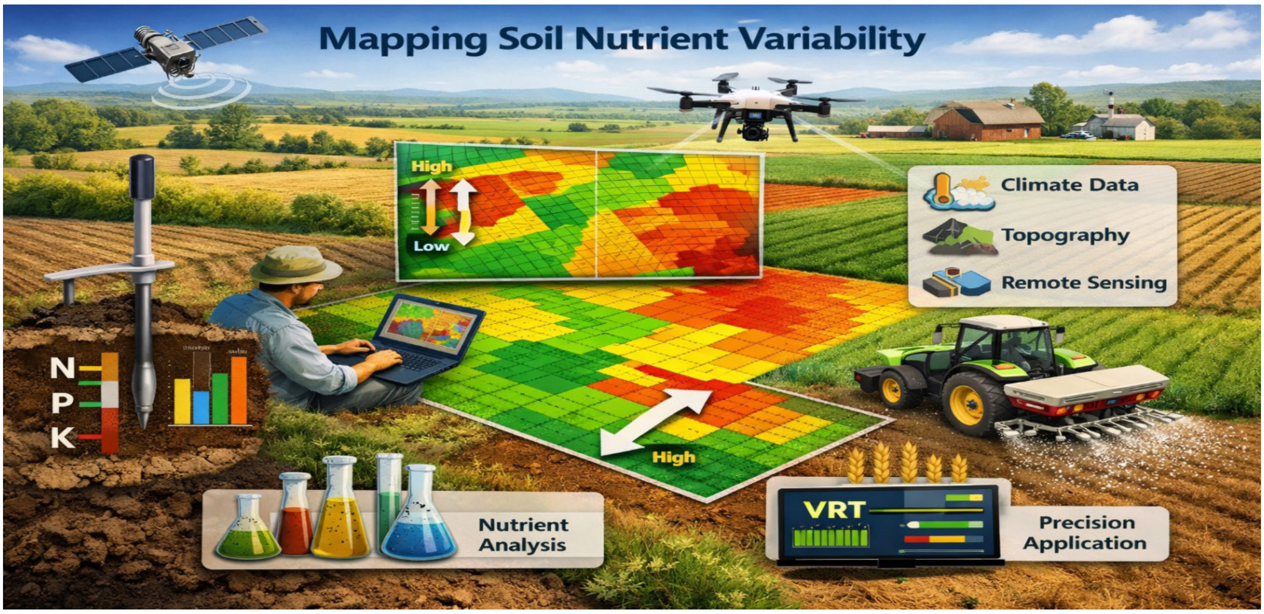
Tools and Technologies Used (GIS, Remote Sensing, Sensors)

Mapping Soil Nutrient Variability

Modern digital soil mapping combines remote sensing (satellites/drones), proximal sensors (EMI, pXRF), and GIS platforms to convert field data into actionable insights. By integrating spatial, soil, and climatic data through advanced analytics, it generates high-resolution maps that support precision agriculture decisions.



Mapping soil nutrient variability enables precision fertilizer application by using GPS-based sampling and geostatistical methods (e.g., Kriging, IDW) to create continuous nutrient maps. These maps identify deficient and rich zones, guiding variable rate application to improve nutrient uptake, reduce costs, and minimize environmental losses.

Site-Specific Nutrient Management: The New Approach

Site-Specific Nutrient Management (SSNM) replaces uniform fertilization with precise, location- and time-specific nutrient application using 4R principles and GPS-based Variable Rate Technology (VRT). By

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addressing soil variability, it improves nutrient use efficiency, reduces losses and environmental risks, and enhances crop yield and quality.

Benefits for Farmers and Crop Productivity

Adopting digital mapping and site-specific management transforms the economic and biological potential of a farm by aligning inputs with the actual needs of the crop. For the farmer, the primary benefit is **increased profitability** through the optimization of input costs; instead of over-applying expensive fertilizers to high-performing zones or wasting them on low-potential areas, resources are redistributed to where they generate the highest return on investment. This precision reduces the "yield gap"—the difference between potential and actual harvest—by ensuring that nutrient deficiencies never become a limiting factor for plant growth.

On the level of **crop productivity**, the benefits are seen in the physiological health and uniformity of the stand. When nutrients are applied according to the soil's specific cation exchange capacity and pH, plants experience less salt stress and more balanced uptake, leading to stronger root systems and better resilience against environmental stressors like high temperatures.

- **Higher Nutrient Use Efficiency (NUE):** More of the applied fertilizer ends up in the grain or fruit rather than leaching into the groundwater.
- **Enhanced Quality:** Uniform nutrient availability leads to more consistent protein levels, fruit size, and ripening times across the entire field.
- **Data-Driven Decisions:** Farmers gain a historical "digital twin" of their soil, allowing them to track long-term fertility trends and make informed adjustments for future growing seasons.

Conclusion:

Digital Soil Mapping (DSM) marks a shift from uniform management to high-resolution, site-specific decision-making, enabling better food security and environmental sustainability. By integrating SCORPAN and machine learning, it accurately captures soil variability for precise nutrient application. DSM is evolving into a core technology for sustainable, data-driven agriculture.

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Diseases of medicinal and aromatic plants and their impact on bioactive secondary metabolites.

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Abstract

India possesses a long-standing heritage of using traditional medicinal plants valued for their therapeutic properties. Globally, the demand for medicinal herbs has risen significantly across both urban and rural populations, driven by their potential to enhance immunity and treat diverse ailments. However, overharvesting has pushed many medicinal plant species toward endangerment, underscoring the urgent need for conservation to safeguard their immense medicinal value for future generations. Medicinal and Aromatic Plants (MAPs) serve as essential raw materials for the pharmaceutical, cosmetic, food, and fragrance industries, yet their cultivation is increasingly challenged by biotic stresses caused by fungi, bacteria, viruses, phytoplasmas, insects, nematodes, and weeds. These stresses result in substantial reductions in biomass, deterioration of economically significant plant parts, and decreased concentrations of active compounds.Diseases of MAPs often arise from complex interactions among multiple pathogens, producing symptoms such as chlorosis, stunting, rotting, and lesion formation. These infections disrupt photosynthesis, ultimately leading to significant yield losses and posing a threat to global food and nutritional security. Notable examples include downy mildew of isabgol, which can reduce seed yield by up to 74%, along with major diseases like leaf blight in Ashwagandha and root and stem rot in Safed musli and Aloe vera. Additionally, phytoplasma infections in periwinkle and lemongrass trigger characteristic symptoms such as little leaf, phyllody, floral virescence, and excessive shoot proliferation, leading to severe stunting and loss of floral development. Given the economic and therapeutic importance of MAPs, understanding biotic stress factors and their impact is critical for developing effective management and conservation strategies.

Keywords: Medicinal plants, diseases, fungal, phytoplasma, bioactive molcules.

Introduction:

India has a rich history of utilising traditional medicinal plants with their therapeutic values. The global population, both in urban and rural areas, has witnessed an increased demand for medicinal herbs due to their potential in enhancing immunity and treating various illnesses. This growing recognition of the therapeutic properties of medicinal herbs has led to their widespread use in promoting human health worldwide. Overharvesting has placed many medicinal plant species on the verge of extinction. Preserving these medicinal plants for future generations is of paramount importance, considering their immense potential in treating a wide range of illnesses and providing numerous health benefits. Safeguarding these plants ensures that their valuable properties are available for the well-being of future generations. The pharmaceutical, cosmetic, food, and perfume industries place great importance on sourcing high-quality raw materials from Medicinal and Aromatic Plants (MAPs) for the production of herbal products. However, the cultivation of these plants faces significant challenges due to biotic factors and biotic contribute to biotic stress, leading to substantial losses in biomass yield, degradation in the quality of economically important plant parts, and a reduction in

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the concentration of active ingredients within MAPs. Biotic stress refers to the unfavourable conditions that impede plant growth, arising from interactions with harmful biotic agents such as fungi, bacteria, viruses, viroids, phytoplasmas, insects, nematodes, and weeds.

Diseases of medicinal and aromatic plants:

Microorganisms primarily thrive within or on plant tissues, often causing infections when fungi, bacteria, and viruses act together, leading to severe disease symptoms. The combined infection of these pathogens tends to result in a diverse range of symptoms, including chlorosis, stunting, rotting, and the formation of local lesions. The relationship between plants and pathogens elicits diverse morphological, biochemical, and molecular responses, indicating the activation of multiple signalling pathways. Biotic stressors, such as viral, fungal, and bacterial infections, inflict significant yield losses on major medicinal crops by impairing photosynthesis levels. This results in a significant decrease in productivity. Plant diseases not only impede crop productivity but also present a substantial threat to global food and nutritional security. Downy mildew of isabgol caused by *Pernosporaplantaginis* is reported to induce male and female sterility, and seed yield was reduced up to 74%. Major diseases of the medicinal plants are leaf blight, leaf spot in Ashwagandha, root and stem rot in Safed musli, and Aloe vera **(Figure 1).** Other major diseases of medicinal plants are shown in **Table 1.**

Phytoplasma infection in periwinkle and lemongrass:

Periwinkle and lemongrass are important plants that yield a group of secondary metabolites known as terpenoids, indole, and alkaloids with strong antibacterial or antifungal activity. The phytoplasma-infected plant shows severe, typical little leaf symptoms and phyllody. When phyllody occurs, blooms towards the apex of branches are most severely harmed. Floral virescence, phyllody, and proliferation are the main signs and symptoms of phytoplasma. The floral components transform into thick, leathery, leafy forms and also form small and bunchy leaves, shorter internodes, and the formation of excessive branching from a single point are all signs of little leaves. Plants that are infected do not produce any flowers, which ultimately causes the plants to become stunted. Phytoplasma infestation has also been seen in the lemongrass and Periwinkle **(Figure 2).**

Table 1. Diseases Affecting Medicinal Plants

Medicinal plant	Scientific name	Disease	Casual organism
Ashwagandha	*Withaniasomnifera*	Leaf blight	*Alternaria tenuis*
		Myrothecium leaf spot	*Myrothecium roridum*
		Leaf spot	*Alternaria alternata, Colletotrichum gloeosporioides*
		Root rot	*Macrophominaphaseolina*
		Damping off	*Phytiumaphindermatum*
		Wet rot	*Choanephoracucurbitarum*
		Wilt	*Fusarium solanii*
Giloe	*Tinospora cordifolia*	Leaf spot	*Exserohilumrostratum* *Xanthomonas campestris* *Macrophominaphaseolina*
		Yellow leaf spot	*Corynesporacassiicola*

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Aloe vera	*Aloe barbadense*	Bacterial Soft rot	*Pectobacteriumchrysanthemi*
		Collar and root rot	Sclerotium rolfsii
		Basal root and stem rot	Fusarium solani and F. oxysporium
		Leaf spot	*Alternaria alternate, A. brassicae*
		Anthracnose disease	*Colletotrichum gloeosporioides*
		Rust	*Phakopsorapachyrhizi, Uromyces aloes*
Senna	*Casia angustifolia*	Leaf spot	*Alternaria alternata, Cercospora* sp.
		Damping off	*Rhizoctonia bataticola*
		Dry rot	*Macrophominaphaseolina*
		Leaf blight	*Phyllosticasp.*
		Leaf and pod spot	*Phomopsis* sp.
		Wilt	*Fusarium oxysporum*
Kalmegh	*Andrograhispaniculata*	Leaf blight	*Fusarium lateritium*
		Wart	*Synchytriumlepidagathidis*
		Leaf web blight	*Rhizoctonia solani*
		Root rot	*Macrophominaphaseolina*
		Witches' Broom	Phytoplasma
		Yellow Vein Leaf Curl Disease	Eclipta yellow vein virus
		Leaf spot	*Cercospora* sp.
		Damping off	*Phytiumaphindermatum*
Isabgoal	*Plantago ovata*	Wilt/root rot	*Fusarium oxysporium*
		Downy mildew	*Peronospora plantaginis, P.alta*
		Damping-off	*Phytiumultimum, Rhizoctonia solani, F.oxysporum*
		Powdery mildew	*Erysiphe cichoracearum*
Tulsi	*Ocimum sanctum*	Powdery mildew	*Oidium* sp.
		Seedling blight	*Rhizoctonia solani,*
		Root rot	*Rhizoctonia bataticola*
Lemon grass	*Cymbopogon flexuosus*	Colletotrichum leaf spot	*Collectotrichumcapsici*
		Witches broom	Phytoplasma
Palmarosa	*Cymbopogon martinii*	Leaf blight	*Curvulariatrifolii, C. andropogonis*
		Leaf spot	*Colletotrichum caudataum*
Sarpagandha	*Rauvolfiaserpentiana*	Anthracnose	*Colletotrichum gloesporioides*
		Leaf spot	*Corynesporacassiicola, Macrophominaphaseolina*
		Leaf blight and bud rot	*Alternaria tenuis, A. alternata, Curvularialunata*
		Leaf blotch	*Cercospora serpitinae*
		Die back	*Colletotrichum dematium*
		Root rot	*Macrophominaphaseolina*
		Inflorescence & fruit rot	*Rhizopus stolonifer*

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Shatavari	*Asparagus racemosus*	Leafspot and purple spot	*Stemphylium vesicarium*
		Phytophthora crown, root rot	*Phytophthora asparagi, P. megasperma var. sojae*
		Fusarium crown, root and lower stem rot	*Fusarium oxysporum*sp. *asparagi, F. proliferatum, F. moniliforme, F. solani*
		Rust	*Puccinia asparagi*

Impact of diseases on the bioactive molecules:

Biotic stress leads to a range of visible symptoms, including leaf wilting, root and stem rot, leaf pustules, chlorosis, and tissue necrosis, with many diseases caused by different pathogens showing similar morphological features. These stresses collectively disrupt essential plant processes such as photosynthesis, respiration, transpiration, nutrient uptake, metabolism, biochemical pathways, gene expression, and defence responses, ultimately resulting in reduced yield or even plant mortality. Infected plant tissues often exhibit yellowing, curling, wrinkling, and stunted growth due to alterations in cell wall structure, chloroplast degradation, and hormonal imbalances. Such physiological disturbances lower photosynthetic efficiency and overall plant biomass, while also disturbing nutrient distribution. This shift redirects primary metabolic activity toward secondary metabolic pathways, often enhancing the production of secondary metabolites in medicinal plants. Thus, biotic stress plays a dual role—on one hand increasing certain metabolite levels due to stress, while on the other hand decreasing overall plant growth and productivity.

Figure 1. Diseases of medicinal plants: A) Leaf spot of Safed musli, b) Leaf spot of Giloe, (c) Leaf spot of

Ashwagandha, (d) Leaf spot of Mandukparni, e) Collar rot of Safed musli f) Damping off Kalmegh g) Leaf rot and foot rot of Aloe Vera, i) Wilt of Roselle.

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Figure 2: Phytoplasma infection a) Lemongrass and b) Periwinkle

Exposure to stress conditions induces substantial morphological and ultrastructural modifications in plants, altering growth dynamics, cellular organisation, and photosynthetic efficiency. Structural changes in leaves and cells typically result in decreased photosynthetic rates, reduced productivity, and impaired physiological functions, such as transpiration and stomatal conductance, contributing to leaf wilting. Biotic stress further disrupts source–sink relationships, causing shifts in sink metabolism and increased sugar accumulation, all of which are closely linked to photosynthetic performance. The interplay between carbohydrate metabolism, photosynthesis, and defence responses is evident in the elevated synthesis of secondary metabolites, including phenolics, terpenes, alkaloids, and sulphur-containing compounds, which support antioxidative defence and resistance to pathogens and pests. To survive these challenges, plants activate multifaceted defence strategies, encompassing structural barriers, chemical defences, and genome-driven regulatory responses.

Conclusion: Safeguarding crops against diverse biotic stressors, such as diseases, insect pests, and parasitic flowering plants, remains a major challenge. Elucidating the metabolic adaptations and tolerance mechanisms in plants represents a promising avenue for improving crop protection in medicinal and aromatic plants. Modern omics technologies—including genomics, metabolomics, proteomics, and transcriptomics—provide critical insights into changes in primary and secondary metabolism triggered by biotic stress and are particularly valuable for research in MAPs, where metabolic complexity requires targeted study.

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Floriculture Beyond Flowers: The Multifaceted World of Floriculture.

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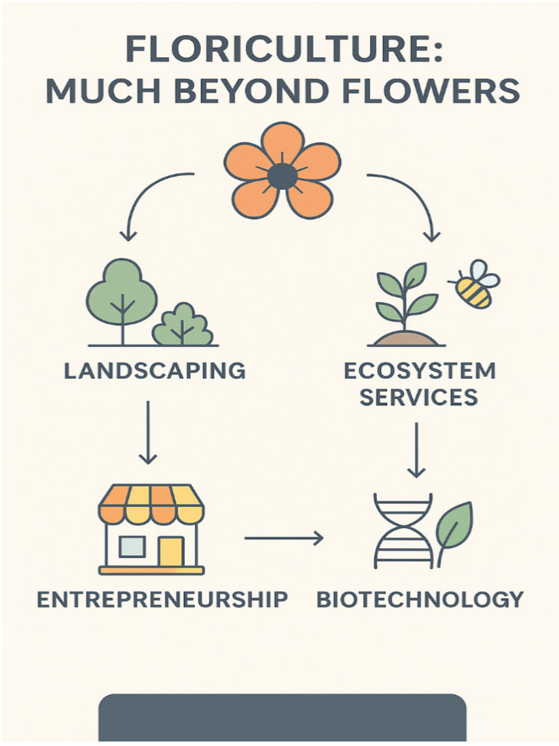
Introduction: Breaking the Bloom Stereotype

When most people hear the word *floriculture*, they picture rows of vibrant flowers destined for bouquets and garlands. While this image holds truth, it barely scratches the surface of what floriculture truly encompasses. Far beyond the aesthetic charm of blossoms, floriculture is a dynamic discipline that intersects with ecology, economy, and innovation.



Today's floriculture is not just about growing flowers—it's about designing resilient landscapes, restoring biodiversity, and building sustainable livelihoods. From rooftop gardens that cool urban heat to native ornamentals that support pollinators, floriculture plays a vital role in ecosystem services. It's also a thriving avenue for entrepreneurship, offering value-added products like essential oils, natural dyes, and biodegradable floral foams.

Moreover, the field is rapidly evolving through biotechnology and precision horticulture. Breeding drought-tolerant varieties, enhancing fragrance profiles, and integrating smart irrigation systems are just a few examples of how science is reshaping the way we grow and use ornamental plants.

In essence, floriculture is much more than flower farming—it's a blooming frontier of sustainability, innovation, and socio-economic impact.

Ecological Impact: Beauty That Sustains : Floriculture plays a vital role in ecological restoration and climate resilience. By integrating native ornamentals and thoughtful landscape design, it becomes a powerful tool for environmental stewardship.

Biodiversity Conservation

- Native ornamentals like *Gomphrena*, *Tecoma*, and *Lantana* support local ecosystems by attracting pollinators such as bees, butterflies, and birds.
- These plants often require fewer inputs (water, fertilizers, pesticides), making them ideal for low-maintenance, ecologically balanced gardens.

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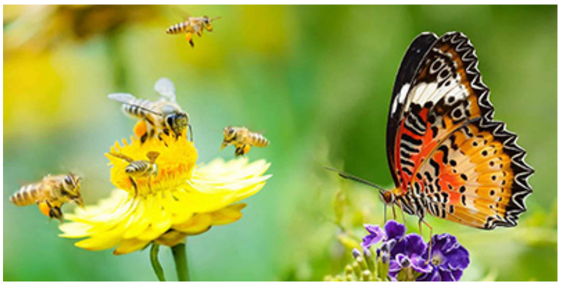
- Floriculture can help reclaim degraded lands, restore floral diversity, and create microhabitats in urban and peri-urban areas.

Climate Resilience & Soil Health



- Green cover from ornamental plants contributes to carbon sequestration, helping mitigate greenhouse gas emissions.
- Strategic planting in urban areas provides shade and cooling, reducing the urban heat island effect.
- Ornamental groundcovers and shrubs improve soil structure, reduce erosion, and enhance microbial activity—key for long-term soil fertility.

Pollinator Corridors

- Floriculture landscapes can be designed as pollinator corridors, linking fragmented habitats and supporting biodiversity.
- This is especially critical in semi-arid regions, where floral resources are seasonal and scarce.

Economic Dimensions: From Petals to Profits

- Floriculture is not just a celebration of beauty—it's a thriving economic sector with diverse opportunities for value addition and entrepreneurship. By tapping into local resources and creative business models, floriculture can empower communities and drive sustainable growth.

Value-Added Products

Ornamental crops offer more than visual appeal—they're raw materials for high-value products:

- Essential oils from aromatic flowers like *Jasminum*, *Rosa*, and *Tagetes* are used in perfumery, cosmetics, and wellness.
- Natural dyes from *Hibiscus*, *Marigold* and *Bougainvillea* are gaining popularity in eco-textiles and crafts.
- Biodegradable floral foams and packaging materials are emerging as sustainable alternatives to plastic-based products.
- Potpourri, dried flower crafts, and pressed flower art create niche markets for home décor and gifting.

Agri-Entrepreneurship Opportunities

Floriculture opens doors for innovative, regionally relevant business models:

- Bouquet services and floral design studios cater to weddings, events, and hospitality sectors.

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- Bee hive integration in ornamental gardens enhances pollination, supports biodiversity, and generates honey and wax products.
- Eco-tourism gardens and sensory landscapes attract visitors, promote conservation awareness, and create employment in rural areas.

These ventures can be scaled from backyard nurseries to export-oriented enterprises, especially when combined with digital marketing, branding, and value chain integration.

Social Impact: Cultivating Communities

Floriculture also holds significant social value by generating employment, improving livelihoods, and enhancing the quality of life in both rural and urban environments.

Women and Youth Empowerment

Floriculture enterprises often require moderate investment and relatively small land areas, making them accessible to women entrepreneurs and young farmers.

Activities such as nursery management, bouquet making, floral decoration, and dry flower crafts provide opportunities for skill-based employment and micro-enterprises. Self-help groups (SHGs) and cooperatives across India are increasingly engaging in floriculture-based businesses, contributing to household income and financial independence.

Urban Well-being and Green Spaces

In cities, ornamental horticulture contributes significantly to mental health and environmental quality.

• Urban gardens and landscaped parks provide recreational spaces that improve physical and psychological well-being.
• Rooftop and balcony gardens enhance air quality and reduce urban heat.
• Therapeutic horticulture programs are increasingly used in hospitals, rehabilitation centers, and educational institutions.

By reconnecting people with nature, floriculture plays an important role in building healthier and more livable cities.

Future Prospects: A Blooming Horizon : As the world faces climate change, biodiversity loss, and increasing urbanization, the role of floriculture is likely to expand far beyond ornamental value.

Future directions may include:

• Climate-smart ornamental crops adapted to extreme weather conditions.
• Integration with urban agriculture, promoting green roofs and vertical gardens.
• Biophilic city planning, where ornamental plants become central elements in urban design.
• Metabolomics and molecular research to understand pigment pathways, fragrance compounds, and stress tolerance in ornamental species.

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Additionally, consumer demand is shifting toward eco-friendly and sustainably produced floral products, encouraging the adoption of organic cultivation, biodegradable packaging, and carbon-neutral production systems.

Conclusion: Beyond the Beauty of Flowers

Floriculture is no longer confined to the cultivation of decorative blooms—it has evolved into a multidisciplinary field that bridges ecology, economics, technology, and social development.

By promoting biodiversity, generating income opportunities, improving urban environments, and embracing scientific innovation, floriculture demonstrates how ornamental plants can contribute to a more sustainable and resilient future.

What begins as a simple flower in bloom ultimately grows into something far greater: a symbol of harmony between nature, scienceand society.

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From Temple to Table: The Many Wonders of Bael

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Abstract

Bael (*Aegle marmelos*) is an indigenous fruit tree of the Indian subcontinent known for its cultural, nutritional, and medicinal importance. Traditionally associated with religious rituals, the plant has long been valued in Ayurveda for treating digestive and other health disorders. The fruit is rich in dietary fiber, vitamins, minerals, and bioactive compounds with antioxidant properties. Bael is highly adaptable to arid and semi-arid regions and requires minimal inputs, making it suitable for sustainable and climate-resilient agriculture. In addition, its genetic diversity offers opportunities for crop improvement and value-added product development such as beverages and herbal formulations. Despite its potential, bael remains underutilized, highlighting the need for increased research, conservation, and commercialization to promote it as a functional and economically valuable fruit crop.

Keywords: ayurveda, conservation, nutritional, Bael

Introduction

For centuries, bael has occupied a sacred space in Indian culture. Its trifoliate leaves are offered to Lord Shiva, and the tree is often found growing near temples, symbolizing purity and devotion. Yet beyond its spiritual significance lies a fruit of immense nutritional, medicinal, and scientific value. Known botanically as *Aegle marmelos*, bael represents a remarkable example of how traditional wisdom and modern research can intersect to address contemporary needs in nutrition, health, and sustainable agriculture.

Methodology : The present article was prepared using a review-based approach. Relevant information on bael (*Aegle marmelos*) was collected through an extensive review of available scientific literature. Data were gathered from reliable sources such as peer-reviewed research articles, review papers, books, and authentic online databases related to horticulture, ethnobotany, nutrition, and medicinal plants. Published reports from recognized journals, institutional publications, and traditional knowledge documented in scientific studies were carefully examined. The collected information was analyzed and compiled to present a comprehensive overview of the cultural significance, nutritional value, medicinal uses, and economic importance of bael. Only credible and verified sources were considered to ensure the accuracy and authenticity of the information presented in this article

An Indigenous and Resilient Fruit Tree : Bael is indigenous to the Indian subcontinent and is well adapted to diverse agro-climatic conditions. It thrives in arid and semi-arid regions, tolerates high temperatures, and performs well even in marginal soils where many commercial fruit species fail. This resilience makes it particularly valuable in the context of climate change and water scarcity. Unlike high-input horticultural crops, bael requires relatively low management, making it suitable for dryland farming and resource-poor regions.

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The tree itself is hardy and long-lived, capable of producing fruits for many decades. Such characteristics position bael as an important candidate for sustainable horticultural systems and agroforestry models

.A Nutritional Treasure

Bael fruit is more than just a traditional delicacy. It is rich in carbohydrates, dietary fiber, vitamins, and essential minerals. The pulp contains bioactive compounds such as phenolics, flavonoids, and tannins, which contribute to its antioxidant properties. These compounds play a role in neutralizing free radicals and supporting overall health. Traditionally, bael has been valued for its digestive benefits. Ripe fruit pulp is consumed as a refreshing beverage during summer, while unripe fruit preparations are commonly used in traditional medicine to manage gastrointestinal disorders. It's cooling effect and restorative properties have been recognized in Ayurveda for centuries. Today, scientific studies increasingly support these traditional claims, reinforcing the relevance of bael in modern nutritional science.

Plant part	Traditional preparation	Therapeutic use
Unripe fruit	Powder or decoction	Treats diarrhea and dysentery
Ripe fruit	Juice or pulp	Relieves constipation
Leaves	Juice or paste	Reduces blood sugar and inflammation
Bark	Decoction	Used for fever and cardiac disorders
Roots	Infusion	For respiratory and bronchial ailments
Flowers	Extract	Cardiotonic, menstrual regulation
Seeds	Paste	Topical for skin infections

Table 1: Traditional uses of Bael

From Traditional Remedy to Functional Food

In recent years, there has been growing global interest in functional foods, foods that provide health benefits beyond basic nutrition. Bael fits naturally into this category. Products such as bael squash, nectar, powder, candy, and ready to serve beverages are gaining popularity. Its unique aroma and flavor profile further enhance its market potential. With increasing consumer awareness about natural and plant based health products, bael offers promising opportunities for value addition and commercialization. Developing standardized processing techniques, improving shelf life, and ensuring quality control can further expand its reach in domestic and international markets.

Table 2: Marketed herbal formulations containing *Aegle marmelos*

Product name	Company	Key ingredients	Claimed therapeutic use
Vilvadi Lehya	Arya Vaidya Sala	*A. marmelos*, *Terminalia chebula*, *Tinospora cordifolia*	Digestive tonic, antidiarrheal
Dasamula Rasayana	Himalaya	*A. marmelos*, *Withania somnifera*, *Tribulus terrestris*	Immunomodulator, vitality enhancer
Bael Sharbat	Patanjali	*A. marmelos* pulp	Digestive beverage for summer ailments
Bael Churna	Dabur	Dried *A. marmelos* fruit powder	Natural antidiarrheal and laxative
Bilvadi Taila	Baidyanath	*A. marmelos*, *Azadirachta indica*	Antiseptic and wound-healing oil

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Fig 1: Medicinal market products of *Aegle marmelos*

Diversity and Research Potential

One of the most fascinating aspects of bael lies in its genetic and phenotypic diversity. Natural populations exhibit considerable variation in fruit size, pulp color, sweetness, seed number, shell thickness, and overall yield. Such variability provides a rich foundation for selection and crop improvement. Methodical characterization of bael germplasm can help identify superior genotypes with desirable traits such as higher pulp recovery, better taste, enhanced nutritional quality, and improved tolerance to abiotic stresses. Conservation of this diversity is equally important, as habitat loss and neglect of indigenous crops threaten valuable genetic resources.

Economic and Sustainable Importance

Beyond its health benefits, bael holds significant economic value. Its adaptability to harsh environments makes it suitable for cultivation in regions where few fruit crops can thrive. This opens avenues for diversifying farming systems and enhancing rural livelihoods. Bael cultivation can contribute to income generation through fresh fruit sales as well as processed products. It's long shelf life in raw form further adds to its commercial viability. Moreover, promoting indigenous fruit crops like bael supports biodiversity conservation and reduces dependence on exotic species that may require intensive inputs. In the broader context of sustainable agriculture, bael exemplifies a crop that aligns with environmental resilience, nutritional security, and economic sustainability.

A Fruit for the Future

Despite its immense potential, bael remains underutilized and often overlooked in mainstream horticulture. Increased awareness, scientific validation, and policy support are essential to promote its cultivation and

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commercialization. Strengthening research on genetic improvement, value addition, and supply chain development can accelerate its transition from a traditional fruit to a modern functional commodity. As global agriculture move towards climate smart and nutrition sensitive approaches, indigenous species like bael deserve renewed attention. The journey of bael from temple rituals to household tables symbolizes a broader transformation, one that bridges heritage and innovation. Reviving interest in bael is not merely about promoting a fruit; it is about recognizing the wealth embedded in traditional biodiversity. By integrating cultural legacy with scientific advancement, bael can emerge as a model crop for sustainable and health oriented food systems in the twenty first century.

Fig 2: Field view of *Aegle marmelos* tree bearing mature and immature fruits

Results

The review of available scientific literature highlights that *Aegle marmelos* possesses significant cultural, nutritional, and medicinal importance. The collected information indicates that the fruit is rich in bioactive compounds and has well-documented therapeutic uses in traditional medicine. Studies also reveal its adaptability to harsh environmental conditions, making it suitable for sustainable agriculture. Overall, the findings suggest that bael has strong potential for wider cultivation, value addition, and use as a functional food crop.

Conclusion

Bael is a valuable indigenous fruit that combines cultural significance with remarkable nutritional and medicinal properties. Its adaptability to harsh climatic conditions and low input requirements make it an important crop for sustainable agriculture. The fruit also offers promising opportunities for value addition and functional food

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development. However, despite its immense potential, bael remains underutilized in mainstream horticulture. Greater research, awareness, and commercialization efforts are needed to promote this traditional fruit as a resource for nutrition, health, and rural livelihood.

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Post-Harvest Losses In Fruits, Vegetables, Spices And Plantation Crops : opportunities For Mitigation And Value Recovery

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ABSTRACT

Post-harvest losses (PHL) severely undermine food availability, farmer incomes and agricultural sustainability in India. Fruits and vegetables suffer the greatest quantitative losses due to their perishability, while spices and plantation crops often suffer quality degradation that reduces market value. Recent national assessments and market analyses show that improving cold-chain infrastructure,adopting low-cost storagetechnologies, and strengthening value-chain organisation can dramatically reduce losses. This article reviews current evidence, recent advancements (past 3–5 years), and practical mitigation strategies. It concludes with recommendations for stakeholders — farmers, extension agents, policy makers — to harness opportunities for loss reduction and value recovery.

INTRODUCTION

In India's agrarian economy, much emphasis is placed on increasing production, but effectivepost-harvest management(PHM) remains the weakest link.According to the latest global and national assessments, a substantial portion of produce — especially perishables islost before it reaches consumers (FAO,2023). Fruits and vegetables losea largeshare zofyield due to highr espiration rates, fragility and poor handling, while spices and plantation crops suffer quality degradation (aroma, colour, moisture) during drying, storage and transport (Sasikumar, 2015; Afoakwa, 2014). Reducing PHL is not just atechnical matter but a powerful lever to improve food security, nutritional access, farmer incomes, and resource use efficiency. For small holder farmers, where margins are slim, even modest reductions in losses can make a critical difference (ICRIER, 2020). Recent years have seen increasing attention to PHM — through supportive policies, technological innovations, and market-oriented solutions. This article synthesises recent evidence and advances (last ~5 years), and presents actionable pathways for stakeholders.

THE SCALE OF LOSS—CURRENT FINDINGS

Evidence from recent national-level studies shows:

- Amulti-commodity study by a leading national consultancy (2020–22) estimates that losses across agri-produce in India run into several thousand crores of rupees annually (NABCONS, 2022).
- Horticultural produce — fruits and vegetables — remains among the most vulnerable. In weak cold-chain contexts, losses from harvest to retail frequently range between 20–40% (FAO, 2023).
- Importantly, the scale of loss is not uniform; it varies a cross crop type, region, harvest season,

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handling practices, and post-harvest infrastructure. These findings highlight that PHL is a systemic issue — with large economic and social stakes — rather than a series of isolated incidents.

WHY HARVESTED CROPS GET WASTED

Understanding causes of PHL helps in designing effective interventions. Major drivers include:

- **Physiological vulnerabilities**: Fruits and vegetables continue to respire after harvest; high moisture and ethylene sensitivity accelerate senescence and spoilage (Kader & Rolle, 2004).
- **Mechanical injuries & rough handling**: Harvesting, transport and handling in jute/gunny bags cause bruises, cuts and crushing, exposing produce to microbial invasion and faster decay (Arah et al., 2015).
- **Inadequate infrastructure**: Lack of pre-cooling, cold storage, temperature- controlled transport, and pack-houses forces many perishables to travel long distances in ambient heat (MoFPI, 2025).
- **Poor processing & storage for spices/plantation crops**: Traditional sun-drying, open-airstorage, moisture fluctuations and lack of hygienic conditions cause lossof quality — affecting aroma, colour, oil content and export grade (Sasikumar, 2015; Thamkaew, 2021).
- **Fragmented value chains & weak market linkages**: Many smallholders are compelled to sell produce quickly at low prices due to lack of storage or market access, often before optimal maturityor after quality deterioration (ICRIER, 2020).

RECENT PRACTICES & ADVANCEMENTS (2020–2025)

In the past few years, improvements in policy, technologyand organisational models have shown promise in reducing PHL across diverse contexts. Key developments:

- **Cold-chain expansion & modern logistics**: A recent market assessment reveals growing investment and adoption of cold-chain technologies for fruits and vegetables both CAPEX-driven and pay-per-use (refrigerated transport, reefer vans, multiproduct cold-storage) under supportive government schemes (CLASP / NCCD, 2023).
- **Zero-energy cooling for smallholders (ZECC/ECC)**: Evaporative cooling chambers using brick-sand construction remain a low-cost, energy-free solution for short-termstorage. Recent studies confirm their usefulness for extending shelf life of vegetables and leafy greens — though effectiveness varies with climate (Ghosh et al., 2023; Singh & Yadav, 2025).
- **Improved drying & processing for spices and herbs**: Advances in hybrid solar- biomassdryersand controlled-temperature drying systems have improved retention of volatile oils, colour and overall quality — reducing quality-based losses that previously caused heavy price reductions or rejection (Ahmed & Zaman, 2021; Thamkaew, 2021).
- **Farmer Producer Organisations (FPOs) & shared infrastructure models**: Group-level aggregation

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enables smallholders to pool resources, access cold-chain facilities or drying units, and negotiate better market access, making investments viable even at small production scales(ICRIER,2020;MoFPI scheme reports2024– 25).

- **Digital market linkages & price-forecasting platforms**: Emerging platforms offering near real-timede mand–supply data help farmers decide optimal harvest to market timing reducing distress sales and gluts that otherwise lead to losses. While stillnascent, pilot data suggests mode streduction in wastage where adopted (industry reports 2023–24).

WHAT WORKS PRACTICAL STRATEGIES FOR FARMERS & EXTENSION

Strategy/ Intervention	SuitableFor	KeyAdvantages
Integrated Cold-Chain (pre-cooling reefervans→cold storage)	High-volume/high-value horticultural produce(fruits, vegetables)	Significantly extends shelf life; preserves quality; enables access to distant markets at betterprices
Zero-Energy Cool Chamber (ZECC/ECC)	Small holders, low-volume producers,remote/humidity controlledregions	Very low cost; no electricity; extends shelf life for leafy vegetables/fruit for a fewdays
Improved drying & hygienic processing for spices & herbs	Spice growers,small-scale processors	Maintainsaroma,volatileoil content, dryweight; preserves qualityandexport-gradevalue
Group-based aggregation: FPOs / cooperatives	Small/marginal farmers; low-volume producers	Enables shared infrastructure/ investment; better bargaining power; reduces individual risk
Valueaddition&processing (juices, dried products, powders)	Farmers with surplusor lower-grade produce	Converts perishable/low-grade produce into higher-value, longer-shelf products — increases income, reduces waste
Market-information & linkage platforms (digital/whatsapp based)	Produce traders and farmers	Helps plan harvest→transport →sale; reduces distresssales and mismatched supply/demand-leading to wastage

CHALLENGES AND CAUTION POINTS

- Cold-chain infrastructure requires **high throughput and volume** to be financially viable; for smallholders or fragmented production zones, standalone cold storage may not pay off (CLASP report, 2023).

- ZECC effectiveness depends heavily on **climate** — in high humidity / monsoon- prone areas the cooling effect reduces, limiting shelf-life extension (ZECC case studies under humid tropics).

- Many smallholder farmers lack **capital, awareness or collective organisation** to adopt storage/ drying infrastructure or value-addition. Institutional support and training are often required.

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- For spices and plantation crops, **quality losses are often "invisible"** — small declines in a romatic oils or moisture may not be evident immediately, but cause large price drops at export or wholesale markets. Rigorous drying, storage and quality control must be adopted to realize gains.

- **Policy and credit access** remainpatchy. Subsidy schemes, credit lines and technical support are essential for wide adoption, especially among marginal farmers and in remote areas.

RECOMMENDATIONS FOR STAKE HOLDERS

- **Farmers&FPOs**: Explorelow-coststorage(ZECC), invest in improved packaging (ventilated crates), coordinate harvests for batch sale,considers implevalue -addition (drying, processing) for surplus produce.

- **Extension agents & researchers**: Document local PHL quantitatively; test and promote appropriate storage/drying/handling systems adapted to regional climate and cropping patterns; train farmers in best PHM practices.

- **Policymakers & planners**: Expand cold-chain infrastructure not just for primary cold stores but upstream pack-houses, pre-cooling units, transport/reefer networks; provide credit/subsidy support for small holders and FPOs; prioritize value-addition and rural agro-processing.

- **Market institutions & private sector**: Collaborate with farmer groups to build shared infrastructure (pack-houses, processing units), implement Cooling-as-a- Service (CaaS) models, support market-information platforms for better supply– demand matching.

CONCLUSION : Post-harvest losses are not merely agricultural "wastage" — they represent lost food, lost income, wasted resources and reduced nutritional and market value. However, recent advances in cold-chain logistics, affordable cooling technologies, improved drying & processing forspices,and moreorganisedvalue-chain models provide realistic pathways to plug this leak. For India — with its agrarian economy, large smallholder base and diverse agro-ecologies — effective post-harvest management offers one of the most cost-efficient opportunities to boost food security, farmer welfare and sustainable agriculture. With coordinated efforts from farmers, extension services, policy makers and market actors, post- harvest losses can be transformed from a persist entproblemin to a manageable challenge— turning waste into value.

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Kitchen Garden: A Simple Pathway To Nutritional Security

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Introduction: Balanced nutrition is very important during all the stage of life for a hale and healthy life which cannot be sustained without adequate nourishment. Nutritional deficiencies are most prevalent in rural areas where habitual diets lack variety and they cannot afford to diversify their diets due to lower purchasing power. The sustainable solution to their problem lies in the improvement and diversification of household diet by growing kitchen gardening. The role of agriculture in enhancing nutrition is highly recognized although the evidence of its contribution remains weak and mixed. Increasing on-farm production diversity is perceived as an effective approach towards improving smallholders' diet diversity and nutrition.

Kitchen gardens are found in many humid and sub-humid parts of the world. They are sometimes called backyard or home gardens. These gardens have an established tradition and offer great potential for improving household food security and eliminating micronutrient deficiencies. Gardening can enhance food security in several ways, most importantly through: 1) Direct access to a diversity of nutritionally-rich foods, 2) Increased purchasing power from savings on food bills and income from sales of garden products and 3) Fall -back food provision during seasonal lean periods.

Malnutrition and micronutrient deficiencies continue to be among the most pressing health challenges in India, particularly affecting children, women, and the elderly. Despite progress in food production, rising prices and heavy dependence on grain-based diets often leave families with limited access to fresh vegetables and fruits, resulting in poor dietary diversity and hidden hunger. In this context, kitchen gardens-small, home-based plots established in backyards, terraces, pots, or even community spaces emerge as a simple yet powerful solution. They provide households with year-round access to fresh, pesticide-free vegetables and fruits, ensuring not just food security but nutritional security, which means having diets rich in quality, variety, and essential nutrients rather than just sufficient calories. By supplying vital vitamins and minerals such as iron, vitamin A, vitamin C, and calcium, kitchen gardens directly strengthen immunity, support growth, and improve overall well-being. Most importantly, they benefit vulnerable groups like children, women and the elderly, who are often the first to suffer from nutritional deficiencies. Thus, the humble kitchen garden stands as a low-cost, sustainable and resilient approach to improving household health and nutrition while reducing dependence on the market.

Literally, 'Kitchen gardens' refer to food grown in or around the house for household use . Home gardens may be a kitchen garden, mixed gardens, or backyards, farmyard and compound gardens or homestead gardens. Kitchen or home gardening is the earliest and most extensive food production system found throughout the world.

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Role of kitchen garden in nutritional security

Kitchen gardens directly contribute to better nutrition by: Ensuring year-round availability of fresh vegetables, improving dietary diversity with leafy greens, roots and fruits, providing micronutrient-rich foods that help prevent anemia, vitamin deficiencies, and lifestyle diseases, reducing dependency on market-purchased vegetables, Supporting women's empowerment and family health

Benefits of kitchen gardening

Kitchen gardening offers a wide range of benefits that touch nutrition, economy, health, and society. By growing fresh, pesticide-free vegetables at home, families can ensure a better intake of essential vitamins and minerals, directly improving their diets and overall well-being. Economically, kitchen gardens help reduce household food expenses by cutting down on market purchases, while any surplus produce can be shared with neighbors or even sold for extra income. Beyond nutrition and savings, these gardens promote healthy eating habits, encourage regular physical activity through gardening tasks and serve as a tool for women's empowerment by giving them greater control over household nutrition and resources. At the community level, kitchen gardening strengthens social bonds and fosters collective responsibility for better health.

Vegetables that can be grown in a kitchen garden

A kitchen garden can be filled with a wide variety of easy-to-grow crops that ensure a diverse and nutritious diet for the family. Leafy vegetables such as spinach, amaranthus and fenugreek provide essential iron and vitamins, while common vegetables like tomato, brinjal, okra and beans add flavor and variety to daily meals. Root crops including carrot and radish are excellent sources of fiber and minerals and herbs such as coriander, mint and curry leaves not only enhance taste but also offer medicinal benefits. Together, these plants make the kitchen garden a practical, sustainable source of fresh produce right at home.

Simple tips to start a kitchen garden

It can be grown in available space like backyard, terrace, pots or sacks. The compost can be prepared from kitchen waste and seasonal vegetables can be chosen for better yield with regular watering and sunlight.

Proven impact of kitchen gardens

These gardens significantly improved household nutrition, dietary diversity and economic savings. Families practicing organized kitchen gardening produced 3 to 4 times more vegetables than traditional methods, increasing per capita consumption from about 150 to 240 g/day with raising intake of key nutrients like protein, iron, calcium, vitamin A, vitamin C and folic acid. Malnutrition indicators like anemia, stunting and wasting of muscle among women and children declined notably as per certain reports. Economically, households saved Rs. 3000 – 5000 annually as well as reduced market dependency and sharing with neighbours. The training programs through extension units like Krishi Vigyan Kendras empowered rural women, enhanced knowledge of improved varieties, organic practices and seasonal planning, while overcoming constraints like seed quality and water scarcity. Overall, the collective findings confirm that kitchen gardens are a low-cost, sustainable and community-driven solution to combat malnutrition and strengthen nutritional security in rural India.

Challenges and solutions:

- Lack of space can be overcome by using containers on terrace gardening
- For water scarcity, drip irrigation or recycled water can be used

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- The lack of knowledge can be improved by participating in training programs by extension and research units

Conclusion: Kitchen gardens are a low-cost, sustainable and empowering solution to tackle malnutrition and ensure nutritional security. They provide families with fresh vegetables, reduce expenses and improve health outcomes. Schools, households and communities should adopt kitchen gardening as a movement towards a healthier and self-reliant future.


Kitchen garden


Terrance garden


Palak


Ridge gourd


Tomatoes with trellising


Broad beans

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Latest schemes for Agriculture in budget 2025

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Abstract

Union Finance Minister Nirmala Sitharaman has termed the agriculture sector as the first engine of growth and announced schemes where she announced schemes of which the Prime Minister Dhan-Dhaanya Krishi Yojana--a scheme that is likely to benefit 1.7 crore farmers in 100 districts with low crop production--for the sector in the Budget presented in Parliament. Some of the key schemes that are announced by the finance minister in Agriculture scheme are Prime Minister Dhan-Dhaanya Krishi Yojana,Mission for Aatmanirbharta in Pulses and the modified interest subvention scheme for farmers which help the farmers financially. This Budget highlights agriculture as one of the power engines of the economy and presents an ongoing plan to boost agricultural productivity and growth, strengthen rural India and foster prosperity for the farmers, support MSMEs, enhance export capabilities, spur innovation, promote the advancement of women, improve digital and technological expertise, expand infrastructure, and improve farmers' access to credit.

Key words : Interest Subvention, Krishi , Kisan credit card, Atmanirbharata, Pulses

Prime Minister Dhan-Dhaanya Krishi Yojana:

It is a mission for districts having lower crop production, moderate crop intensity, and not enough credit access. Overall, the total budget for agriculture increased marginally.The PM Dhan-Dhanya Krishi Yojana is designed to improve farming in areas where productivity is low. The scheme is inspired by the success of the Aspirational Districts Programme. It aims to make farming more productive and sustainable. It will use current government programs and add new measures to cover several important areas like: crop yield,diversification, post harvest management, irrigation and financial or credit support to the farmers.

Main goals: The scheme is made to make farming more productive by better farming practices and technologies.Encourage farmers to grow different kinds of crops so they can become profitable and reduce risks from a single type of crop. Expanding ecologically friendly farming practices that take care of the soil, save water, and reduce the use of chemicals. Building better facilities at the local and block level to reduce the losses that happen after harvesting. Ensuring more farmlands receive adequate water supply to increase the efficiency of farming. Give short-term and long-term loans to farmers that will empower them to invest in better seeds, technology, and other infrastructure. Empower the rural dweller with skills, investment, and technology so that they do not have to move to urban areas.

The salient features of this scheme are : The program shall be implemented across 100 aspirational districts in the country characterized by low agricultural productivity and average crop intensity. It will integrate already existing government schemes to create an all-round improvement in farming. Storage facilities developed at local and block levels that reduce post-harvest loss. Expansion of irrigation infrastructure as well as irrigation system to distribute water efficiently during farming.

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The significance of this scheme is that this initiative will increase average crop output at the district level, making food available on the market side. Diversifying and more environmentally-friendly farming makes agriculture less hazardous and risk-proof. Appropriate storage structures reduce crop loss and ensure better returns to the farmer. Improved irrigation facilities will help in increasing the yields of farmers and with the credit facilities available to the farmer on time helps the farmers in better productivity using proper tools, seeds and requisite infrastructure and by proper means of training and investment reduces the need for migration with a special focus on small and marginal farmers, rural women, and landless families lead to inclusive growth and fair development. With improved storage and processing helps the farmers in realizing better markets and enhanced storage and processing facilities can help farmers realize a better price for their produce by value addition and linking them to markets. International technical and financial help by adopting more modern practices makes the sector more advanced and the scheme will not only boost farming but also make the rural areas self-sufficient and robust.

Mission for Aatmanirbharta in Pulses: The Finance Minister has announced the launch of a six-year 'Mission for Aatmanirbharta (self-reliance) in Pulses. With an allocation of 1000 crore and its aim is to boost the output and help achieve self-sufficiency in pulses, with special focus on Tur, pigeon-pea, Urad ,black gram and red lentil. It will provide minimum support price (MSP)-based procurement and post-harvest warehousing solutions. India's Target: India has set a target to end India's dependence on imports to meet the country's pulses demand by 2029. In 2023-24, imports went up 84% higher year-on-year to 4.65 million tonnes, the most in six years. In value terms, the country's spending on imports rose 93% to $3.75 billion. India largely imports from countries Canada, Australia, Myanmar, Mozambique, Tanzania, Sudan and Malawi.

India is the largest producer (25% of global production), consumer (27% of world consumption) and importer (14%) of pulses in the world. Pulses account for around 23% of the area under food grains and contribute around 9-10% of the total food grains production in the country. Where Rabi pulses contribute more than 60% of the total production .

Challenges

Pulses traditionally has been a neglected crop because of the low yields and their instability, pulses are considered a residual crop and are grown grown under rain-fed conditions in marginal/less fertile lands, with very little focus on pest and nutrient management. With the onset of green revolution rice and wheat got promoted where it used external inputs and pushed pulses to the brink of marginal lands leading to a decline in the productivity and land degradation combined with the lack of breakthrough in pulses crops which led to lower benefit cost ratio for the pulses and the penetration and adoption of HYV are low and combined with post harvest losses caused due to the excess moisture and attack caused by stored grain pests .

Measures taken by government to increase production

National Food Security Mission: The Department of Agriculture & Farmers Welfare is implementing the National Food Security Mission (NFSM)-Pulses with the objectives of increasing production through area expansion and productivity enhancement in all the districts. PM-AASHA: Government implements an umbrella scheme PM-AASHA comprising Price Support Scheme (PSS), Price Deficiency Payment Scheme (PDPS) and Private Procurement Stockist Scheme (PPSS) in order to ensure Minimum Support Price (MSP) to farmers for their produce of notified oil-seeds, pulses and copra. Model Pulses Villages: According to the

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agriculture ministry's plan to achieve self-sufficiency, model pulses villages will be set up from the current kharif or summer-sown season. Use of Fallow Land: The ministry is also working with states to bring fallow land for cultivation of lentils. Hubs: It is set to create 150 hubs to distribute high-yielding seeds. Alongside, the farm department will collaborate with the department of agricultural research to promote climate-resilient varieties.The government has to ensure crop diversification and incentivize farmers sufficiently across varieties to stop imports.

Modified interest subvention scheme: The Loan limit under the Modified Interest Subvention Scheme (MISS) has been increased from Rs 3 lakh to Rs 5 lakh. The MISS Scheme: The farmers engaged in agriculture and other allied activities can acquire Kisan Credit Card (KCC) loans up to Rs 3 lakh at a benchmark rate of 9 per cent (A 2 per cent interest subvention on the benchmark rate is provided) An additional 3 per cent concession for prompt and timely repayment further reduces it to 4 per cent per year.

Conclusion : The Kisan Credit Card scheme has been instrumental in transforming agricultural credit accessibility, ensuring that farmers receive timely and affordable financial assistance. By increasing financial support under the Union Budget 2025-26, the government is reinforcing its commitment to empowering farmers. These initiatives not only promote agricultural growth but also enhance rural livelihoods, paving the way for a resilient and self-sufficient farming community in India. The Mission for Atma Nirbharta in Pulses is a significant step toward reducing India's dependence on imports. However, achieving self-reliance in pulses requires addressing agronomic challenges, policy ambiguities, and climate vulnerabilities. The success of the mission will depend on effective implementation, technological advancements, and farmer-centric policies. The Prime Minister Dhan-Dhaanya Krishi Yojana (PMDKY) is a transformative step towards improving India's agricultural landscape. By focusing on productivity, irrigation, storage, and financial access, the scheme aims to empower 1.7 crore farmers and ensure sustainable rural development. While challenges remain, effective coordination between central and state governments and timely implementation of initiatives will be key to the scheme's success. If executed efficiently, PMDKY has the potential to make India's agricultural sector more resilient, productive, and financially secure.

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Alarming Levels of Chemical Contaminants in India and Telangana's Groundwater

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Abstract:

Groundwater is a vital source of water for millions of people in India, yet its quality is increasingly under threat from chemical contamination. This article explores the growing concern of groundwater pollution, with a focus on major contaminants such as fluoride, nitrate, salinity, and trace metals. It highlights how both natural geological processes and human activities—particularly agriculture, industrial discharge, and improper waste management—contribute to the degradation of groundwater quality. Special attention is given to Telangana, where widespread fluoride and nitrate contamination has made groundwater unsafe in several districts. The article also discusses the hidden nature of these pollutants, their long-term health impacts, and the challenges associated with detection and remediation. Methods such as Water Quality Index (WQI) and Entropy Weighted WQI (EWQI) are briefly introduced as tools for assessing water quality. By combining scientific insights with a people-centered perspective, the article emphasizes the urgent need for sustainable groundwater management, increased public awareness, and effective policy implementation. Protecting groundwater resources is essential not only for environmental sustainability but also for safeguarding public health and future water security.

Introduction: Groundwater is an essential resource for human survival and plays a critical role in public health (Ravindra *et al*., 2022). In India, nearly 90% of rural populations and a significant portion of urban communities depend on groundwater for their daily needs (Senthilkumar *et al*., 2024). However, the quality of groundwater is increasingly under threat due to both natural (geogenic) processes such as water–rock interaction and human (anthropogenic) activities including the use of fertilizers, improper waste disposal, and industrial effluents (Sinha *et al*., 2023). Among the various contaminants, fluoride (F^-) and nitrate (NO_3^-) are the most common and pose serious health risks (Egbueri *et al*., 2023). Unlike surface water, groundwater moves very slowly, allowing pollutants to persist for long periods. As a result, contamination often goes unnoticed until it reaches dangerous levels (Gulgundi and Shetty, 2019). Once polluted, groundwater may remain unsafe for decades, and its restoration is both difficult and expensive (Mishra *et al*., 2005). To assess groundwater quality, scientists use laboratory analysis of physicochemical parameters along with indices such as the Water Quality Index (WQI), which provides a simplified measure of overall water quality (Zotou *et al*., 2018; Susaiappan *et al*., 2021).

Role of Central Ground Water Board (CGWB):

The Central Ground Water Board (CGWB), under the Ministry of Jal Shakti, is the primary organization responsible for monitoring and managing groundwater resources in India. It maintains a nationwide network of observation wells to track groundwater levels and quality. The CGWB also provides technical guidance and

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supports sustainable groundwater management practices.(**Source: https://vajiramandravi.com/current-affairs/groundwater-contamination-in-india-nitrate-and-chemical-pollutants/)**

India and Telangana-Groundwater quality:

Groundwater contamination in India has emerged as a major environmental and public health challenge. India is the largest user of groundwater globally, extracting nearly one-fourth of the world's total groundwater to support drinking, irrigation, and industrial needs. Over 600 million people depend on groundwater daily. However, excessive extraction and human activities have led to widespread contamination. Recent analyses indicate that: About 19.8% of groundwater samples exceed nitrate limits, 13.2% exceed iron levels, 9.04% exceed fluoride limits, 6.6% exceed uranium limits and 3.55% exceed arsenic limits. Salinity is another major issue, particularly in arid and coastal regions. Emerging contaminants such as PFAS have also been detected in urban areas like Chennai **(Husain and Yadav, 2026).**

❖ **Major Contaminants and Their Sources: (Source: https://cgwb.gov.in/hi/ground-water-quality)**

Groundwater contamination in India is caused by both natural and human-induced factors:

Nitrate: The most widespread contaminant, mainly due to excessive use of fertilizers and improper waste disposal. Around 20% of samples exceed the permissible limit of 45 mg/L.

Fluoride: Occurs naturally in rocks and is common in hard rock regions. About 8% of samples exceed safe limits (>1.5 mg/L).

Salinity (EC): High electrical conductivity indicates dissolved salts, especially in arid regions like Rajasthan and Gujarat.

Arsenic: A major concern in the Ganga–Brahmaputra basin due to geogenic sources.

Uranium (U): High uranium concentrations (exceeding 30 ppb) were reported in states including Rajasthan, Punjab, Haryana, Andhra Pradesh, and Telangana.

Manganese (Mn): Exceedance of Manganese was reported across multiple states like Assam, Karnataka, Odisha, Uttar Pradesh, and West Bengal.

Telangana is one of the most affected states in terms of groundwater contamination, particularly due to fluoride and nitrate pollution.

Fluoride contamination (>1.5 mg/L) is widespread in districts such as Nalgonda, Adilabad, Mahabubnagar, Medak, and Rangareddy.

Nitrate contamination is observed in most districts, with Adilabad, Nalgonda, and Vikarabad being highly affected.

High **salinity** (EC > 3000 µS/cm) is reported in districts like Jangaon, Kamareddy, and Nagarkurnool.

Chloride levels exceeding 1000 mg/L are found in Nalgonda and Jogulamba Gadwal.

These conditions make groundwater unsafe for drinking and irrigation in many regions.

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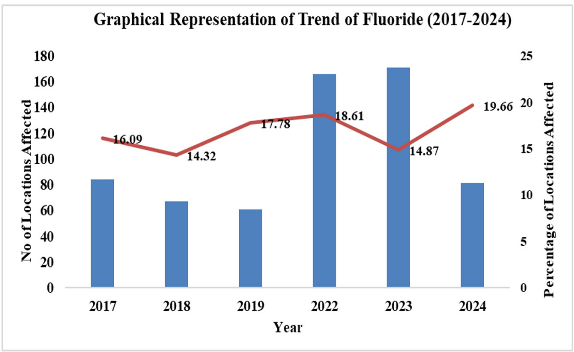

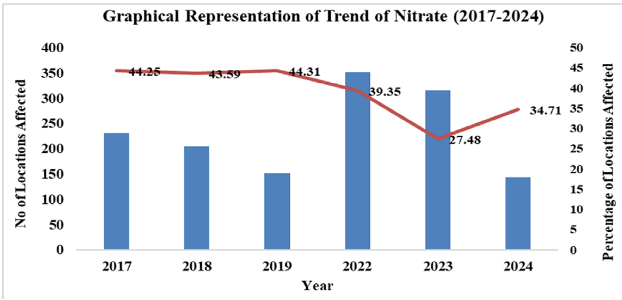

Trend of Fluoride and Nitrate in Telangana (Source: https://cgwb.gov.in/cgwbpnm/)

- **Assessment of Groundwater Quality:**

EWQI Calculation-Entropy Weighted Water Quality Index (Singha *et al.*, 2025)

$$EWQI = \sum_{j=1}^{m} w_j * \left(\frac{M_i}{S_i} \times 100\right)$$

It is an advanced water quality index method that:

* Assigns weights based on information entropy

* Reduces subjective errors

* Identies most influential contaminants

Where, Mi and Si are the measured concentration of physicochemical parameter and desirable limit for a particular parameter as per BIS. Entropy weight (wj)

EWQI results express groundwater quality as a single overall score for each location, derived from selected parameters and their relative significance using entropy weighting. Higher EWQI values reflect poorer water quality.

Groundwater pollution index: (Periasamy *et al.*, 2024)

$$WP = \frac{RW}{\sum RW} \quad \text{........................} \ (1)$$

$$SOC = \frac{C}{DWQS} \quad \text{........................} \ (2)$$

$$OQG = WP \times SOC \quad \text{..........................} \ (3)$$

Finally, the GPI has been calculated by summing the values of OQG (Eq. 4).

$$GPI = \sum OQG \quad \text{....................................} \ (4)$$

Relative weight (RW);

Weight parameter (WP)

Status of concentration (SOC)

- **Remediation of Groundwater Pollution: (Chinchmalatpure *et al.*, 2019)**

Several methods are used to treat contaminated groundwater:

1. Phytoremediation: Uses plants to absorb and stabilize contaminants through processes such as phyto-accumulation and phyto-degradation. Plants like *Salix acmophylla* are effective in removing heavy metals.

2. Microbial Remediation: Microorganisms break down pollutants into less harmful substances. For example, *Klebsiella pneumoniae* can remove heavy metals.

3. Chemical Methods: Adsorption (Using activated alumina or carbon) and Coagulation (Using lime and alum for fluoride removal)

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Conclusion:

Groundwater contamination is no longer a localized or isolated issue, but a widespread and growing problem in India, especially in Telangana and other semi-arid regions. Groundwater, which is considered a safe and reliable source of water, is increasingly affected by chemical contaminants due to both natural and human-induced factors. Prolonged consumption of groundwater with high fluoride and nitrate levels can lead to serious non-carcinogenic health problems. The use of assessment tools such as Water Quality Index, multivariate statistical analysis, GIS mapping, and health risk assessment provided valuable insights into identifying contamination hotspots and understanding controlling mechanisms. Need for continuous groundwater monitoring, sustainable groundwater management, and effective remediation strategies.

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Spices And Herbs: Flavour Enhancers And Power Packed Nutraceuticals In Diets

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Introduction: The use of spices and herbs has been incredibly important from times immemorial for their medicinal properties even before culinary use. Modern science has now shown that many of them do indeed carry remarkable health benefits.

Spices: Spices are aromatic, flavourful plant-based items used in cooking to enhance taste and as natural preservatives. Beyond flavour, they offer significant health benefits that include powerful anti-inflammatory, antioxidant and anti-diabetic properties.

Cinnamon: Cinnamon is a popular spice, found in all sorts of recipes and baked goods. It lowers blood sugar levels and has a powerful anti-diabetic effect. It contains a compound called cinnamaldehyde which is responsible for cinnamon's medicinal properties. It has potent antioxidant activity that helps fight inflammation and has been shown to lower cholesterol and triglycerides in the blood.

Cinnamon can lower blood sugar by slowing the breakdown of carbohydrates in the digestive tract and improving insulin sensitivity. Studies have shown that cinnamon can lower fasting blood sugars by 10.0 – 29.0 % in diabetic patients to a significant amount. The effective dose is typically 0.5 – 2.0 teaspoons or 1 – 6 g of cinnamon / day.

Cardamom: Cardamom helps in improving digestion, support respiratory health and is an antioxidant powerhouse due to its rich antioxidants and essential oils that help fight bacteria, reduce inflammation, lower blood pressure and provide detoxifying properties for skin and body organs. It aids in clearing congestion, soothing coughs, enhancing skin complexion and potentially boosting metabolism thus making it a versatile spice for wellness.

It has diuretic properties that help to flush toxins, improving kidney health and promoting glowing skin. The antibacterial properties fight bad breath, cavity-causing bacteria and thus acts as a natural mouth freshener.

Cloves: Cloves are highly aromatic flower buds widely used for its culinary, medicinal and aromatic applications. They are a rich source of eugenol providing antioxidant, anti-inflammatory and antimicrobial benefits. It is commonly used in seasoning curries, meats and desserts, aids digestion, treats dental pain as clove oil has natural antiseptic properties, reduced bad breath and boosts respiratory health as it acts as an expectorant to treat coughs and colds. It is high in antioxidants and manganese that help reduce inflammation and strengthen the immune system.

Pepper: Pepper is used to prepare spicy dishes. The active ingredient in it is called capsaicin, which has been shown to reduce appetite and increase fat burning in many studies. For this reason, it is a common ingredient in many commercial weight loss supplements. Studies showed that 1.0 g of pepper added to meals reduces appetite and increases fat burning in people who did not regularly eat pepper. However, there was no effect in people who were accustomed to eating spicy food indicating that a tolerance to the effects can build up. Some

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animal studies have also found that capsaicin can combat certain cancers.

Ginger: Ginger is a popular spice used in several forms of alternative medicine. It can treat nausea and has anti-inflammatory properties. Studies have consistently shown that 1.0 g or more of ginger can successfully treat nausea. This includes nausea caused by morning sickness, chemotherapy and sea sickness. It appears to have strong anti-inflammatory properties and can help with pain management. One study in subjects at risk for colon cancer found that 2.0 g ginger extract per day decreased markers for colon inflammation in the same way as aspirin. Other research found that a mixture of ginger, cinnamon, mastic, and sesame oil decreased pain and stiffness experienced by those with osteoarthritis. It had a similar effectiveness as treatment with aspirin or ibuprofen.

Garlic: It can combat sickness and improve heart health. Throughout ancient history, the main use of garlic was for its medicinal properties. The health benefits are due to a compound called allicin which is also responsible for garlic's distinct smell. Garlic supplementation is well known for combatting sickness, including the common cold. For those with high cholesterol, garlic supplementation appears to reduce total and/or LDL cholesterol by about 10.0 - 15.0 %. Human studies have also found garlic supplementation to cause significant reductions in blood pressure in people with high blood pressure.

Turmeric: Turmeric is the spice that gives curry its yellow colour. It contains several compounds with medicinal properties, the most important of which is curcumin with powerful anti-inflammatory effects. Curcumin is a remarkably powerful antioxidant, helping to fight oxidative damage and boosting the body's own antioxidant enzymes. This is important, because oxidative damage is believed to be one of the key mechanisms behind ageing and many diseases. Curcumin is also strongly anti-inflammatory, to the point where it matches the effectiveness of some anti-inflammatory drugs. Studies suggest that it can improve brain function, fight Alzheimer's, reduce the risk of heart disease and cancer and relieve arthritis.

Coriander seeds: Coriander seeds are versatile, aromatic culinary spices and traditional remedies used for improving digestion by relieving gas and bloating due to its carminative properties, manage blood sugar, reduce inflammation and lower cholesterol levels. They are commonly used in curries, soups and spice blends, while seeds soaked in water serve as a detoxifying and cooling drink. The quercetin and tocopherols present in these seeds help to combat inflammation and oxidative stress.

Its culinary benefits include use as a spice blend as key ingredient in garam masalas, curry powders and seasoning mixes. It flavours roasted vegetables, pickles, soups and stews with its citrusy and nutty flavour. The roasting of these seeds enhances its aroma and flavour during use curries and seafood. It is also used to flavour breads and baked goods.

Cumin: Cumin contain flavonoids that work as antioxidants in the body to help neutralize unstable particles called free radicals that cause cell damage thereby preventing diseases like cancer, heart disease and high blood pressure. It is used to aid digestion, treat diarrhoea, reduce inflammation, may help in weight loss and managing cholesterol levels. Cumin oil is sometimes used in fragrances, perfumes and flavour alcoholic beverages.

Fenugreek: Fenugreek was commonly used in Ayurveda, particularly to enhance libido and masculinity. While its effects on testosterone levels are inconclusive, fenugreek does seem to have beneficial effects on blood sugar. It contains the plant protein 4-hydroxyisoleucine, which can improve the function of the hormone insulin. Many human studies have shown that at least 1.0 g of fenugreek extract per day can lower blood sugar levels particularly in diabetics.

Nutmeg: Nutmeg is a versatile spice used y for enhancing the taste of sweet and savoury dishes globally.

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Beyond cooking, it acts as a traditional, nutrient-rich remedy for improving digestion, promoting sleep, reducing inflammation, managing blood sugar and boosting libido. Nutmeg butter derived from the seed is used in perfumery and toothpastes. The use of nutmeg powder along with honey or milk on the skin can help control excess oil and remove pigmentation. Nutmeg is safe to consume in small amounts of 1/4 to 1/2 teaspoon daily, but excessive consumption can lead to side effects like nausea or dizziness.

Mace: Mace is the lacy, reddish-orange covering of the nutmeg seed offering a delicate, citrusy and warm flavour used in many foods. It is a staple in spice blends like garam masalas, curries, stews, creamy sauces, pickles and baked goods. It enhances the flavour of meat dishes, sausages, lamb korma, meatballs, soups and rice dishes. It can be added to tea, hot cider, mulled wine and for preserving foods. It is also used in perfumes and soaps.

Bay leaves: Bay leaves are aromatic leaves used primarily to infuse depth to dishes like soups, stews, sauces and braises. Beyond cooking, they are used in traditional medicine to aid digestion, relieve respiratory congestion, and reduce inflammation and in aromatherapy to promote relaxation. They provide a subtle woody and herbal flavour to long-simmered dishes. It is commonly added to meat, poultry and vegetable broths as well as ideally used in pasta sauces (marinara), béchamel and rice dishes. It is used to flavour pickles and braised meats. The dried leaves when placed in pantry jars or drawers can repel insects.

Herbs: Herbs are nutrient dense plants rich in antioxidants, anti-inflammatory compounds and antimicrobial properties that support immunity, digestion and stress management. The maximum benefit can be obtained by adding fresh herbs at the end of cooking to preserve their volatile compounds. The commonly used herbs, their properties and usage in cookery are as follows:

Table 1: **Herbs, its properties and usage in cookery**

S. No.	Name of herb	Properties	Usage in cookery
	Basil / Tulasi leaves	Aromatic with a floral with slightly clove-like flavour	Perfect for pesto, pizzas and Caprese salad.
	Coriander leaves	Fresh and citrusy flavour	Used in Mexican, Latin, and Indian dishes as fresh leaves
	Curry leaves	Mild, aromatic and slightly bitter flavour	Used in Indian cuisine for seasoning, preparing of masala and ready to eat spice mixes
	Parsley	Versatile with a light and peppery taste	Used to garnish or as flavour base in many cuisines
	Rosemary	Woody and pungent	Used in roasted meats, soups and stews
	Thyme	Earthy and subtle	Can be used in meat and vegetables dishes as pairs well with any savoury
	Mint	Cool and refreshing	Used in sweet and savoury dishes in Middle Eastern, North African and south Asian cookery
	Oregano	Strong and pungent flavour	Essential for Italian and Mediterranean cooking especially on pizzas and pasta
	Sage	Peppery and earthy	Famous in stuffings with pork and brown butter sauces
	Dill	Distinctive feathery fronds	Popularly used in fish, pickles and salads
	Chives	Mild onion flavour	Great for garnishing eggs, potatoes and soups

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Various herbs:


Tulasi leaves


Coriander leaves


Rosemary


Thyme


Mint


Oregano


Sage


Dill


Chives

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Success Story Of A Farmer Who Have Achieved Higher Yields Under Cultivation Of Acid Lime And Vegetables.

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ABSTRACT

Natural farming avoid investment on costly chemicals and pesticides. Mr.K. Sivaramaiah, adopted natural farming from the past 9 years. He attended various trainings organized by department of agriculture and Krishi Vigyan Kendra, Vonipenta. After that he prepared 15 types of organic inputs, bio fertilizers, bio pesticides on his farm. Acid lime and Vegetable crops were cultivated in 10 acres area by using the organic inputs. He got net income of Rs.1.5 lakhs /ac from acid lime and from Vegetable cultivation. Rs.80,000 /ac.

Keywords: Natural farming, organic inputs and economics

Crop/ Variety/ Enterprise : Mr.K.Sivaramaiah adopted organic farming from the past 9 years who had been motivated from his uncle who is doing natural farming. So he continued in this farming. Acid lime and vegetable crops in 10 acres of area. He also having two cows and 20 poultry birds

S.No	Crop	Area (acres)
1	Acid lime	8
2	Vegetable crops	2
	Total	**10 acres**

Name of the Farmer(s) and Address (if any):

Mr.K.Sivaramaiah, S/O- T.Kothapalli village, Mydukur mandal, YSR district, Andhra Pradesh, Phone number : 9848558193

Introduction

Chemical fertilizers and pesticides destroy soil health, farmers who rely on them need more and more every year to grow the same amount of crops and increase the cost of cultivation. These rising costs can trap farmers in inescapable debt. Organic farming practices reduce pollution, conserve water, reduce soil erosion, increase soil fertility, and use less energy. Farming without pesticides is also better for nearby birds and animals as well as people who live close to farms also it gives quality of the fruits & vegetables. organic farming is a production system, which avoids or largely excludes the use of synthetically compounded fertilizers, pesticides, growth regulators and livestock feed additives. to the maximum extent feasible, organic farming system rely on crop rotation, crop residues, animal manures, legumes, green manures, off-farm organic waste, and aspects of biological pest control to maintain soil productivity and tilth to supply plant nutrients and to

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control insects, weeds and other pests.

KVK Intervention / institutional involvement

Mr.K.Sivaramaiah, a successful organic farmer residing in T.Kothapalli village of Mydukur Mandal, YSR District . He belongs to farming community and completed his BA in 2011. After that he worked in RTPP thermal as contract employee for the period of two years, Marketing sales executive in Escort tractor company for a period of 2 years He has not getting satisfaction from that job so he left the job & started farming from 2014. He gradually learned the advantages of organic farming and also known the disadvantages of in chemical farming which he had done for 2 years. He believed organic farming reduce cost of cultivation, improve soil health and achieve sustainability in cultivation of various crops. Then he attended training programme on organic input preparation at Krishi Vigyan Kendra, Vonipenta, Subhash Palekar natural farming training in Guntur, Natural farming sessions in Kadapa and also participated in exhibitions, Kisan melas and Krishi Kalyan Abhiyaan organized by the Department of Agriculture. He learned and gained knowledge on organic inputs preparation and organic cultivation with this experience he started organic farming in Acid lime and Vegetable crops since 2016. During the year 2022 his mother-in-law was awarded 3rd prize in recognition of the exemplary performance and achievement in the category of Organic and Natural farming from Jaivik India Awards 2022 with the support KVK, Vonipenta.

Success Point/Results :

Mr.K. Sivaramaiah Garu has prepared 16 types of organic inputs (Beejamrutham, Ghanajivamrutham, Dravajivamrutham, panchagavya, Agniastram, Neemastram, vavilaku, Panchapatra, Dasaparni, Sonti pala, Saptankura kasayam, Fish amino acids, Egg and lemon amino acids , Starch liquid and Fam Yard Manure mixed with Turmeric) in the farm. He has prepared and use the biofertilizers like PSB, KSB, *Azospirillum* and bio pesticides *Beauveria bassiana, Verticillium lacanii, Metarhizium anisopliae, Trichoderma viride and pseudomonas fluorescence.* Farm waste converted into manure. Followed Intercropping in Acid lime and Vegetable crops.

ECONOMICS

ECONOMIC DETAILS PRIOR TO ORGANIC FARMING				
Crop	**Yield/ac**	**Cost of cultivation (Rs/ac)**	**Gross income (Rs/ac)**	**Net income (Rs/ac)**
Acid lime	3.0 tonnes	1,00,000/-	1,80,000	80,000
Vegetable crops	--	50,000/-	90,000	40,000
Cows	70 L/month	1,000	7,000	6,000
Poultry	20 birds	1000/year	60,000	59,000

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ECONOMICS WITH ORGANIC FARMING				
Crop	Yield/ac	Cost of cultivation (Rs/ac)	Gross income (Rs/ac)	Net income (Rs/ac)
Acid lime	3 tonnes	30,000/-	1,80,000	1,50,000
Vegetable crops	--	20,000/-	1,00,000	80,000
Cows	90 L/month	1000	9000	8000
Poultry	20 birds	1000/year	60,000	59,000

Outcome:

- K. Sivaramaiah Garu garu engaged in production of inputs at their farm. Therefore, cost of cultivation is reduced as compared to spraying of pesticides/fungicides to control pest and diseases.
- Because of better taste, flavour and quality, produce are sold at premium price in the markets.
- By seeing his success 30 farmers adopt organic farming practices in their fields.

Horizontal spread of technology (Extension aspects)

- Department of Agriculture, horticulture and ATMA conducted exposure visits to the farm
- Selected as a resource person for the training to the farmers conducted by the department of agriculture and horticulture.
- Published his success story under Padipantalu magazine.
- Motivated Nearly 30 farmers to adopt organic farming from various mandals of YSR district
- Acted as L2 for 6 villages in Duvvur panchayat under APCNF

Conclusion:

- Organic method of cultivation has reduced dependence on external inputs and created high marked demand and additional nutritional value and taste for the produce.
- He got net income of Rs.1.5 lakhs /ac from Acid lime and from Vegetable cultivation Rs.80,000 /ac.

Quality Photographs

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Preparation of Turmeric and Farm Yard Manure solution and spraying for control of Mite infestation in Citrus

His family members involved in preparation of Dasaparnikashayam

Products for Neemastra preparation

Providing Bio-fertilizers to the farmer from KVK, Vonipenta

His natural produce -Harvested Acid lime and Vegetables

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The Role of Indigenous Knowledge in Climate-Smart Agriculture

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Abstract

Indigenous knowledge, rooted in centuries-old traditions and local experiences, plays a pivotal role in climate-smart agriculture (CSA). As climate change continues to threaten global food security and agricultural sustainability, integrating indigenous practices with modern scientific approaches offers a resilient pathway to adapt and mitigate its impacts. This article explores how indigenous knowledge contributes to CSA by promoting sustainable land management, enhancing biodiversity, conserving water, and fostering soil health. Through comprehensive case studies from diverse regions, this paper underscores the importance of recognizing, preserving, and integrating indigenous practices into contemporary agricultural strategies to build a climate-resilient future. The article also discusses the challenges and opportunities in mainstreaming indigenous knowledge within modern agricultural systems, emphasizing the need for collaborative research and policy support.

Keywords: Indigenous Knowledge, Climate-Smart Agriculture, Sustainability, Biodiversity, Soil Health, Water Conservation, Policy Integration, Collaborative Research

Introduction

Climate change poses a significant threat to global agriculture, impacting crop yields, biodiversity, and food security. In response, climate-smart agriculture (CSA) has emerged as a holistic approach that aims to sustainably increase agricultural productivity, enhance resilience, and reduce greenhouse gas emissions. While technological innovations play a crucial role in CSA, the value of indigenous knowledge systems—rooted in local traditions, culture, and experience—is increasingly recognized as a complementary asset in climate adaptation and mitigation strategies.

The Concept of Indigenous Knowledge

Indigenous knowledge encompasses the skills, practices, and wisdom developed by local communities over generations. It is context-specific, dynamic, and involves a deep understanding of ecological processes and sustainable resource management. Unlike conventional scientific knowledge, indigenous practices are adapted to local environments and have proven effective in managing environmental uncertainties and climate variability. These systems are often interwoven with cultural and spiritual values, enhancing community resilience and social cohesion.

Contributions of Indigenous Knowledge to Climate-Smart Agriculture

1. **Sustainable Land Management:** Indigenous practices such as agroforestry, shifting cultivation, and terracing reduce soil erosion, enhance soil fertility, and promote carbon sequestration. These practices not

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only improve land productivity but also support ecosystem stability.

2. **Biodiversity Conservation:** Traditional seed-saving techniques and crop diversity enhance agricultural resilience to pests, diseases, and climate stresses. By preserving genetic diversity, indigenous communities maintain a pool of adaptable species that can withstand adverse climatic conditions.

3. **Water Management:** Indigenous irrigation methods like 'Ahar-Pyne' systems in India, 'Qanats' in Iran, and 'Waru Waru' in Peru demonstrate efficient water use and conservation. These systems optimize water distribution while minimizing evaporation and soil salinity.

4. **Soil Health Improvement:** Organic composting, crop rotation, mulching, and the use of natural fertilizers by indigenous communities maintain soil productivity and health. These practices enhance soil microbial activity, prevent nutrient depletion, and reduce dependence on chemical inputs.

Case Studies: Global Examples of Indigenous Knowledge in CSA

- **India:** The Zabo system of farming practiced by the Angami tribe in Nagaland integrates livestock management, rainwater harvesting, and soil conservation, promoting sustainable agriculture. It showcases a closed-loop system where livestock waste is recycled as manure, enriching the soil.

- **Andes Region, South America:** The use of ancient Incan terracing techniques has helped maintain soil stability and productivity in high-altitude environments. These terraces control water runoff, prevent erosion, and create microclimates favorable for diverse crops.

- **Kenya:** The Maasai community's traditional livestock management practices contribute to pastureland conservation and reduce overgrazing. By rotating grazing areas, they maintain pasture health and biodiversity, ensuring long-term sustainability.

Challenges and Opportunities in Integrating Indigenous Knowledge

Despite its proven benefits, indigenous knowledge faces challenges such as erosion of traditional practices, lack of formal recognition, and limited integration with modern agricultural research. Globalization, migration, and changing socio-economic dynamics further threaten the preservation of traditional knowledge systems. However, opportunities lie in documenting indigenous practices, fostering collaborative research, and developing policies that recognize and integrate these systems into mainstream agricultural strategies. Public awareness, education, and capacity-building initiatives can enhance the acceptance and application of indigenous knowledge in CSA.

Conclusion

Indigenous knowledge is a valuable resource in the quest for climate-smart agriculture. By blending traditional practices with modern technologies, agricultural systems can become more resilient, sustainable, and adaptable to climate change. Policies and programs that support indigenous communities and promote their knowledge systems are critical in achieving global agricultural sustainability and food security. Collaborative research and policy frameworks that bridge traditional knowledge with scientific innovation will play a crucial role in realizing the full potential of indigenous practices in CSA.

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Regenerative Agriculture

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ABSTRACT

Regenerative agriculture represents a transformative approach to farming that seeks not only to sustain agricultural productivity but also to restore and enhance the natural systems on which food production depends. This article explores regenerative agriculture as a holistic practice centered on soil health, biodiversity, water conservation, and climate resilience. By working in harmony with natural processes—through practices such as cover cropping, crop diversification, rotational grazing, and reduced chemical inputs—regenerative agriculture rebuilds degraded soils and strengthens ecosystem balance. Beyond environmental benefits, the approach empowers farmers economically and socially while contributing to climate change mitigation through carbon sequestration. The article emphasizes regenerative agriculture as a hopeful and practical pathway toward a more resilient, ethical, and sustainable food system.

https://www.cropin.com/wp-content/uploads/2025/07/five-primary-principles-of-re-generative-agriculture-infographic2af2.webp

INTRODUCTION

What Is Regenerative Agriculture?

Regenerative agriculture is more than a farming method; it's a philosophy. At its heart, it asks a simple but powerful question: What if farming could make the land better each year instead of worse?

Rather than relying heavily on synthetic fertilizers, pesticides, and intensive tilling, regenerative agriculture focuses on rebuilding soil health, increasing biodiversity, improving water cycles, and capturing carbon from the atmosphere. It treats farms as living ecosystems where plants, animals, microbes, and people all play a role.

The Soil: A Living World Beneath Our Feet

Healthy soil is not just dirt—it's alive. A single teaspoon of healthy soil can contain billions of microorganisms: bacteria, fungi, insects, and earthworms working together. These tiny life forms break down organic matter, store nutrients, and help plants grow stronger and more resilient.

Conventional farming often disrupts this underground world through excessive tilling and chemical use. Regenerative practices, on the other hand, protect and nourish it. Techniques such as cover cropping, composting, and minimal tillage allow soil life to thrive. As soil health improves, crops become more nutritious, and farms become less dependent on external inputs.

Working With Nature, Not Against It

One of the defining features of regenerative agriculture is its respect for natural processes. Instead of fighting weeds, pests, and weather with chemicals, regenerative farmers design systems that naturally balance themselves.

- Crop diversity prevents pests from spreading easily.
- Rotational grazing allows livestock to fertilize the land naturally while preventing overgrazing.
- Agroforestry integrates trees with crops and animals, providing shade, improving soil structure, and supporting wildlife.

These practices don't eliminate challenges, but they make farms more resilient to droughts, floods, and climate extremes.

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A Powerful Tool Against Climate Change

Agriculture is often seen as part of the climate problem—but regenerative agriculture offers hope. Healthy soils act like sponges, pulling carbon dioxide from the air and storing it underground as organic matter. This process, known as carbon sequestration, can help reduce greenhouse gases while improving soil fertility.

At the same time, regenerative farms use fewer fossil-fuel-based inputs, reducing emissions even further. In this way, farmers become climate stewards, not just food producers.

Farmers at the Center of the Movement

Regenerative agriculture is deeply human. It values farmer knowledge, local traditions, and long-term thinking. Many regenerative farmers speak of renewed pride and purpose in their work. Instead of constantly battling declining yields and rising costs, they see their land recovering—becoming richer, darker, and more alive each year.

Economically, regenerative systems can reduce expenses over time by lowering the need for fertilizers, pesticides, and irrigation. While the transition requires patience and learning, many farmers find it leads to greater independence and stability.

Why It Matters to All of Us

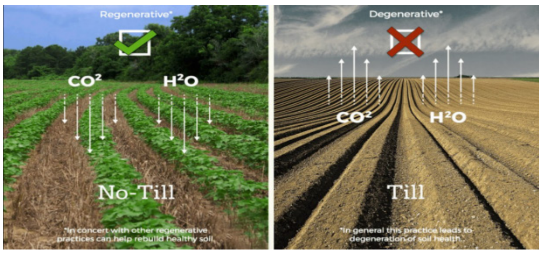
Even if we never step foot on a farm, regenerative agriculture affects us. Healthier soils mean more nutritious food. Cleaner water and air benefit entire communities. Bio-diverse farms support pollinators like bees, which are essential for our food system.

As consumers, our choices matter. Supporting farmers who use regenerative practices—through local markets, sustainable brands, or policy advocacy—helps create demand for food that restores rather than depletes the planet.

Looking Ahead

Regenerative agriculture does not claim to be a perfect or universal solution. But it offers something rare in today's world: a hopeful path forward. It reminds us that humans can be part of nature's healing process rather than its destruction.

By rebuilding our soils, reconnecting with natural systems, and honoring the wisdom of farmers, regenerative agriculture shows that feeding the world and caring for the Earth do not have to be opposing goals. They can, in fact, grow from the same ground.



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METHODS OF REGENERATIVE AGRICULTURE

- **COVER CROPPING**

One important method of regenerative agriculture is cover cropping. When soil is left bare after harvesting, it becomes weak and vulnerable. Cover crops act like a protective blanket, shielding the soil from erosion, conserving moisture, and adding nutrients. These plants quietly prepare the land for the next growing season, ensuring the soil stays alive and fertile.

- **ROTATIONAL GRAZING**

Another key practice is rotational grazing, where animals are moved from one pasture to another instead of grazing in one area continuously. This allows plants time to recover and grow back stronger. The animals, in return, naturally fertilize the soil. It is similar to allowing the land to rest and heal after being used.

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- **COMPOSTING**

Composting is another regenerative method that feeds the soil naturally. Organic waste such as plant remains and animal manure is turned into rich compost. This process is like giving the soil a wholesome meal rather than artificial supplements, helping it regain strength and nutrients.

4. REDUCED TILLAGE

Regenerative agriculture also promotes reduced tillage. Excessive ploughing disturbs soil organisms and damages its structure. By minimizing tillage, farmers protect the underground world of worms, microbes, and roots that work together to support plant growth. It allows the soil to remain stable and healthy.

5.CROP DIVERSITY

Crop diversity plays a vital role as well. Growing different types of crops together strengthens the ecosystem and reduces pests and diseases. Each plant contributes something unique, much like people in a community supporting one another with different abilities.

6. AGRO FORESTRY

Another powerful method is agro forestry, which integrates trees with crops and livestock. Trees provide shade, prevent soil erosion, improve water retention, and support biodiversity. They act as guardians of the land, offering protection and balance.

CONCLUSION

Regenerative agriculture offers a compelling vision for the future of farming—one where agriculture becomes a force for healing rather than harm. By restoring soil vitality, enhancing biodiversity, and strengthening natural cycles, regenerative practices create resilient farming systems capable of withstanding environmental and climatic challenges. Equally important, this approach reconnects farmers with the land, fostering long-term sustainability, economic stability, and environmental stewardship. As global concerns about climate change, food security, and ecosystem degradation continue to grow, regenerative agriculture stands out as a practical and hopeful solution. Embracing and supporting this model can lead to healthier landscapes, more nutritious food, and a more balanced relationship between humans and the Earth.

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From Polyhouses to Geofencing: The Future of Protected Farming in India.

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India's farms are changing. With a population of 1.4 billion and rising food demand, the country's agriculture sector is under pressure to produce more, faster, and smarter. Traditionally, farmers have relied on **protected cultivation** — greenhouses, polyhouses, and shade nets — to shield crops from pests and weather. But these structures cover only about **3.2 lakh hectares**, a tiny fraction compared to the **29.49 million hectares** under horticulture in 2024–25.

Clearly, physical protection alone won't be enough. Enter the next frontier: **digital protected cultivation**.

Why Traditional Protected Farming Falls Short

- **High costs**: Building and maintaining polyhouses is expensive.
- **Limited scale**: Covering vast rice or wheat fields with greenhouses is impractical.
- **Climate risks**: Cyclones, floods, and heavy rains can damage structures.

While effective for high-value crops like flowers or vegetables, these methods struggle to meet the scale of India's staple food needs.

Farming Without Walls: Geofencing & AI

Imagine a rice field in Telangana or a wheat plot in Punjab. Instead of being covered by plastic sheets, the land is surrounded by **digital boundaries** — geofences. Sensors, drones, and cameras feed real-time data into **AI platforms** like ChatGPT or Gemini.

Farmers can monitor:

- Crop growth
- Pest attacks
- Soil moisture
- Weather conditions

All from their smartphones, without stepping into the field.

This isn't science fiction. It's the emerging model of **smart farming**, where digital tools replace physical barriers.

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Traditional vs. Digital Farming

Aspect	Traditional Rice Farming	Geo-Fencing / Precision Farming
Water use	Very high	Reduced by 30–40%
Labour	High	Low (automation)
Input use	Excess / uniform	Targeted / efficient
Cost	High	Slightly higher initially
Yield	Moderate	Higher (10–20% increase)
Profit	Moderate	Higher

Why It Matters

- **Resource savings**: Less water, fewer chemicals, smarter energy use.
- **Higher yields**: Precision farming boosts productivity.
- **Resilience**: Digital systems aren't destroyed by storms.
- **Consumer demand**: Younger generations want healthier, sustainable food.

States like **Telangana**, already leading in rice production, could benefit enormously from these innovations.

The Road Ahead

Government initiatives such as the **Mission for Integrated Development of Agricultural and Bio-Engineering (MIDAB)** and the **National Agricultural and Bio-Engineering Mission (NABM)** could accelerate adoption. With institutional support, India can move from **record harvests** to **sustainable harvests**.

Conclusion

Protected cultivation in India is evolving. The future won't be just about polyhouses and shade nets — it will be about **digital fences, AI-driven insights, and smart drones**. By embracing these technologies, India can feed its growing population while protecting its resources.

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