



# AgriScope

Monthly e-Magazine on Agriculture & Interdisciplinary Sciences

Visit us at : [www.agriscope.in](http://www.agriscope.in)

Email us at : [agri4scope@gmail.com](mailto:agri4scope@gmail.com)



Volume-01

Issue-01

November 2025



## EDITORIAL BOARD

### Editor-in-Chief

Dr. Kajal Kumar Biswas (IARI)

### Managing Editor

Dr. Karishma Baidya (Department of Agricultural Extension)

### Editorial Board Members

Dr. Tanmay Samajdar (KVK, West Bengal)

Dr. Md Mokidul Islam (KVK, Meghalaya)

Dr. Aniruddha Roy (ICAR, Meghalaya)

Dr Yengkhom Linthoingambi Devi (CAU, Imphal)

Dr H G Kencharaddi (CCS Meghalaya)

Dr. Toran Lal Sahu (MGUVV, Raipur)

Dr. Manoj Kanti Debnath (UBKV, West Bengal)

Dr. Shubhm Mishra (BRDPG College, Deoria, Uttar Pradesh)

Dr. Rajeeb Lochan Moharana (OUAT, Odisha)

Dr. Shekhar Dhondiram Khade (BAU, Ranchi)

Dr. Tarun Kumar Das (KVK, Meghalaya)

Dr. Naorem Arunkumar Singh (KVK, Meghalaya)

Dr. Kankabati Kalai (KVK, North Tripura)

Dr. Sagarika Borah (KVK, Meghalaya)

Dr. Puja Chakraborty (KVK, Meghalaya)

Dr. Satarupa Modak (NBB, New Delhi)

Dr. Venkateshwar Jallaph (RVSKVV, CoA, Indore)

Dr. Golmei Langangmeilu (GIET, Odisha)

Dr. Sanjay Chetry (KVK, Meghalaya)

## Index

Article ID.	Article Title	Page
11001	Cotton Farming Crisis Creates Opportunity for Millets Revival in Tribal Odisha	1-3
11002	Sustainable Orchid Cultivation: A Model for Eco-Friendly Farming in the Western Ghats	4-7
11003	The Living Foundation: A Report on the Science, Management, And Future of Soil Health	8-12
11004	The Effects of Intermittent Fasting on Metabolism	13-20
11005	Building A Developed India: Agricultural Pathways to Viksit Bharat 2047	21-24
11006	The Rise of Precision Agriculture: Farming with Data	25-29
11007	Sustainable Agricultural Practices: Farmers' Awareness and the Adoption	30-32
11008	India's Rain Opportunity: Harvesting for A Sustainable Future	33-35
11009	Use of Endophytic Microbes to Promote Crop Production for Eco-Efficient Agriculture	36-41
11010	Rice Monoculture in West Bengal: Historical Development, Current Scenario, and Pathways for Sustainability	42-45

## Cotton Farming Crisis Creates Opportunity for Millets Revival in Tribal Odisha

Shishir Rizal and Golmei Langangmeilu

School of Agriculture, GIET University

Email: [golmei@giet.edu](mailto:golmei@giet.edu)

Article ID: 11001

### Introduction

Rayagada, a tribal-dominated district in southern Odisha, reflects the ecological and economic vulnerabilities of shifting from traditional mixed farming systems to monoculture cotton cultivation. Cotton's promise of quick income has been overshadowed by debt, ecological degradation, and climate-related risks, particularly as unregulated *Bt* cotton seeds spread throughout the region. In contrast, millet cultivation - long marginalized but deeply rooted in tribal agro-ecology- is being revived, supported by community resilience and state-led interventions such as the Odisha Millets Mission (OMM) launch in 2017 and The Shree Anna Abhiyan (SAA), which is a Special programme for the promotion of Millets in Tribal Areas of Odisha.

### Ecological Degradation Under Cotton

1. Soil nutrient depletion due to monoculture and intensive use of inputs.
2. Water stress in a fragile rainfed Agro-ecology.
3. Pest evolution is reducing the utility of illegal *Bt* cotton.
4. Biodiversity loss with the collapse of traditional crop diversity.

### Socio-Economic Pressures

- Debt cycles from high-cost commercial seeds and chemical inputs.
- Market exploitation by middlemen who capture the bulk of cotton's value.
- Institutional neglect due to weak rural banking access and poor extension services.
- Knowledge gaps, leaving tribal farmers vulnerable to misinformation about seed and pesticide use.

### The Millet Revival

With growing mistrust in cotton, farmers are turning back to millets. This return reflects not just an economic necessity, but also cultural pride and nutritional security.

- Cost-effective cultivation: Millets require little external input.
- Resilience to erratic rainfall: Their short cycles match Rayagada's unstable climate.
- Restoration of agro-biodiversity: Millets thrive in intercropping systems, rebuilding ecological balance.
- Nutritive value: Millets provide iron, calcium, and fiber, improving local diets.

- Policy support: Through the Odisha Millets Mission, subsidies, training, and market linkages are improving farmer confidence.

**Table 1: Comparative Overview: Cotton vs. Millets**

Parameter	Cotton (Rainfed)	Millets (Traditional Varieties)	Implications for Farmers
<b>Water Requirement</b>	600 mm (high)	300mm (low)	Cotton depletes scarce water, millets thrive on limited rainfall
<b>Input Costs</b>	High: hybrid seeds, pesticides, fertilizers	Low: largely seed-saved, minimal fertilizer use	Millets reduce dependency on credit and input markets
<b>Pest Vulnerability</b>	High: bollworms, whitefly, pink bollworm (Bt resistance emerging)	Low: generally resilient with diverse varieties	Cotton drives pesticide traps, millets lower risk
<b>Market Dependence</b>	High: heavily controlled by traders/middlemen	Moderate: supported through OMM procurement and local consumption	Cotton exposes farmers to price exploitation, millets ensure food and income security
<b>Soil Health Impact</b>	Negative: monoculture reduces fertility	Positive: supports mixed cropping, restores nutrients	Millets can regenerate degraded land
<b>Climate Resilience</b>	Low: sensitive to erratic monsoon patterns	High: drought, heat and flood resilience crop	Millets provide stability in climate-uncertain environments
<b>Food/Fodder Value</b>	None: cash crop with no local dietary use	High: nutritious staple + livestock fodder	Millets improve household self-reliance
<b>Average Yield</b>	400–600 kg lint/acre (declining over time)	800–1000 kg grain/acre (depending on variety)	Millets often yield more usable produce per acre in rainfed conditions
<b>Risk of Debt</b>	High: input costs + volatile markets	Low: self-seed saving + local utility	Millet adoption reduces indebtedness

### Discussion

The contrast in outcomes between cotton and millets illustrates a fundamental debate within Indian agriculture: the ecological unsuitability of commercial monocultures versus the resilience of traditional, low-input, diverse systems. Cotton has proven to be a maladaptation to Rayagada’s

fragile ecology, fostering financial dependence and ecological crises. Millets, by contrast, align with both ecological necessity and cultural food systems, embodying an intersection of food sovereignty, resilience, and empowerment.



Fig: Millets successfully cultivated by Gunupur Farmers in Rayagada District, Odisha

## Conclusion

The trajectory of Rayagada's cotton crisis underscores the risks of profit-driven monoculture strategies in tribal farming systems. The millet revival, however, demonstrates the possibility of integrating ecological wisdom with modern policy frameworks to secure sustainable rural futures. While cotton amplified ecological risks and economic vulnerability, millets now offer stability, climate adaptation, and greater food-fodder security. This shift represents not a nostalgic return to the past, but an emergent model for sustainable tribal agriculture in India.

## References

- Jena, D., & Mishra, S. (2020). Growth, instability and decomposition of millets in Odisha: 1960-61 to 2017-18. *Odisha economy discussion series*, 7, 23.
- Malik, B. C. (2022). *Review of Odisha Millet Mission: A case study of Bhawanipatna block of Kalahandi District* (Doctoral dissertation, Department of Agricultural Economics, Institute of Agricultural Sciences, Banaras Hindu university Varanasi). 61p.  
<https://ncds.nic.in/sites/default/files/OEDS7NCDS.pdf>  
<https://www.lifegate.com/revival-of-millets-improving-conditions-tribespeople-in-odisha>  
[https://sdgknowledgehub.undp.org/in/wp-content/uploads/2023/04/AGRICULTURE\\_ODISHA\\_DAFE\\_ODISHA-MILLETSS-MISSION.pdf](https://sdgknowledgehub.undp.org/in/wp-content/uploads/2023/04/AGRICULTURE_ODISHA_DAFE_ODISHA-MILLETSS-MISSION.pdf)  
<https://www.downtoearth.org.in/agriculture/making-indias-food-systems-sustainable-in-the-time-of-climate-change>

## Sustainable Orchid Cultivation: A Model for Eco-Friendly Farming in the Western Ghats

Dr. Sabu V. U.

Founder, Eunoia Orchid Garden & Research

Wayanad, Kerala, India

Email: [sabuvuorchid@gmail.com](mailto:sabuvuorchid@gmail.com)

Article ID: 11002

### Abstract

Orchid cultivation, when practiced with ecological awareness and minimal resource input, can emerge as a sustainable livelihood model for the rural communities of the Western Ghats. This article highlights eco-friendly orchid farming techniques developed and adopted in Wayanad, focusing on soil and water conservation, low-input organic practices, and livelihood enhancement of small farmers. Integrating orchid conservation with sustainable agriculture ensures biodiversity protection, aesthetic value addition, and economic empowerment for local growers.

### Introduction

The Western Ghats, one of the eight “hottest hotspots” of biological diversity in the world, host more than 300 species of native orchids, many of which are endemic and threatened. However, habitat destruction, deforestation, and unsustainable collection have led to a decline in their wild populations. Sustainable orchid cultivation provides a nature-based solution—promoting conservation while offering economic benefits to local communities. Eunoia Orchid Garden & Research in Wayanad has pioneered community-based orchid cultivation programs that combine conservation principles with eco-friendly farming. This model emphasizes minimal use of resources, organic growing techniques, and integration with existing cropping systems such as coffee, pepper, and arecanut.

### Eco-friendly Cultivation Practices

Sustainable orchid farming in the Western Ghats relies on the principle of *reduce, recycle, and regenerate*. The following practices have been successfully implemented in low-input orchid cultivation:

#### 1. Use of Natural Substrates:

Locally available organic materials such as coconut husk, tree fern fiber, areca sheath, and leaf litter are used instead of synthetic media. This reduces cost and maintains natural microbial activity essential for orchid growth.

**2. Rainwater Harvesting and Micro-irrigation:**

Orchids require high humidity but minimal standing water. Rainwater harvesting systems and mist irrigation help conserve water while maintaining optimal moisture levels, reducing dependence on groundwater sources.

**3. Organic Nutrient Management:**

Liquid organic fertilizers prepared from cow dung slurry, vermiwash, and fish amino acids are applied through foliar spray. This eliminates the use of chemical fertilizers and sustains soil fertility.

**4. Shade Net Houses and Energy Efficiency:**

Low-cost shade houses made of bamboo and coir netting reduce heat stress and power consumption. Solar-powered mist systems and LED lighting ensure energy-efficient cultivation.

**5. Integrated Pest Management (IPM):**

Neem oil, garlic extract, and biological control agents such as *Trichoderma* are employed to manage pests and fungal infections. This approach avoids banned or synthetic chemicals, ensuring environmental safety.

**Soil and Water Conservation**

Although orchids are epiphytic or lithophytic, soil and water conservation play a crucial role in maintaining microclimatic balance around cultivation zones. Contour bunding, mulching with organic matter, and planting native ferns and mosses around orchid beds help retain soil moisture and prevent erosion. These measures create a self-sustaining microhabitat favorable to both orchids and associated flora and fauna. Additionally, wastewater from orchid misting systems is recycled through natural reed-bed filtration, minimizing water wastage and maintaining farm hygiene.

**Integration with Sustainable Agriculture**

Sustainable orchid cultivation can coexist harmoniously with traditional farming systems. In Wayanad, orchids are cultivated under shade trees of coffee and pepper plantations, utilizing vertical space and creating multilayered cropping systems. This integration offers multiple benefits:

- Diversification of income sources for farmers.
- Enhancement of biodiversity in agricultural landscapes.
- Reduction in the use of synthetic inputs due to ecological balance.
- Promotion of eco-tourism and educational awareness among visitors.

Such integrated models not only preserve native species but also promote farmers as *custodians of conservation*.

### Community Involvement and Livelihood Improvement

A vital component of sustainable orchid farming is community participation. Through awareness programs and training workshops organized by Eunoia Orchid Garden & Research, local farmers and women self-help groups are trained in orchid propagation, potting, and nursery management. Many participants have successfully established small-scale orchid units, generating steady income through the sale of seedlings, flowering plants, and eco-friendly souvenirs. This approach aligns with the Sustainable Development Goals (SDGs) 1 (No Poverty), 13 (Climate Action), and 15 (Life on Land).

### Conservation Impact

Over 600 native orchid species have been successfully replanted in protected zones of the Western Ghats under various community conservation programs. The *Wild Crown* area within Eunoia Orchid Garden acts as a micro-conservation hub preserving endemic and threatened species. By combining research, education, and outreach, this initiative demonstrates how sustainable orchid cultivation can act as a bridge between biodiversity conservation and livelihood security.

### Results and Observations

Field studies indicate that orchids grown under integrated and organic systems show:

- **30–40% lower input cost** compared to conventional nursery models.
- **Higher plant survival rate** due to natural substrate and controlled humidity.
- **Increased biodiversity index** around cultivation zones.
- **Improved income** for participating farmers, especially during flowering seasons.

Such measurable results confirm the ecological and economic viability of this cultivation model.

### Conclusions and Recommendations

Sustainable orchid cultivation in the Western Ghats offers a replicable model for eco-friendly farming. It combines low-input technology, biodiversity conservation, and community empowerment in a single framework. Policymakers and agricultural extension agencies should encourage orchid-based livelihood programs through:

- Training and capacity building for rural youth and women.
- Establishing orchid conservation nurseries under public–private partnership models.
- Promoting certification for organically grown orchids.
- Linking orchid tourism with local conservation education.

Adopting these measures can transform orchid cultivation from a niche hobby into a sustainable agricultural enterprise that nurtures both nature and livelihoods.

### References

- Rao, A.N., & Lee, N. (2017). *Orchids: Science and Horticulture*. Springer.
- Thomas, V., & Kumar, C. S. (2019). *Native Orchids of the Western Ghats: Conservation and Sustainable Use*. Kerala Forest Research Institute.
- Sabu, V. U. (2024). *Community-based Orchid Conservation Initiatives in Wayanad*. Eunoia Orchid Research Reports.

## THE LIVING FOUNDATION: A REPORT ON THE SCIENCE, MANAGEMENT, AND FUTURE OF SOIL HEALTH

Abhay Thakur<sup>1</sup>, Savita Kumari<sup>2</sup>, Nisha<sup>3</sup>, Harshul Jamwal<sup>1</sup> and Anjali Devi<sup>1</sup>

<sup>1</sup>M.Sc. Student, Agricultural Extension Education, COHF, Neri, Dr. YSPUHF, Nauni, Solan, Himachal Pradesh, India

<sup>2</sup>Subject Matter Specialist, Department of Social Sciences, COHF, Neri, Dr. YSPUHF, Nauni, Solan, Himachal Pradesh, India

<sup>3</sup>Teaching faculty, Department of Social Sciences, COHF, Neri, Dr. YSPUHF, Nauni, Solan, Himachal Pradesh, India

Article ID: 11003

### INTRODUCTION: FROM INERT MEDIUM TO VITAL ECOSYSTEM

Modern agriculture is shifting from viewing soil as a static medium to a dynamic, living ecosystem, with implications for productivity, environmental stewardship, food security, and human health. Soil health is defined as "the continued capacity of a soil to function as a vital, living ecosystem that sustains plants, animals, and humans" (NRCS, 2021). This functional perspective focuses on performance i.e. what the soil can do, such as absorbing water, recycling nutrients, suppressing pathogens, and supporting growth.

Healthy soil teems with billions of organisms like bacteria, fungi, protozoa, nematodes, and earthworms, driving essential processes. This biological approach enhances soil's innate capacities, reducing reliance on synthetic inputs. Intensive practices have degraded soil, exacerbating population growth, climate volatility, water scarcity, and biodiversity loss. This report analyzes soil health science, management practices, assessment methods, barriers, and future directions.

### 1. THE FUNCTIONAL SIGNIFICANCE OF HEALTHY SOIL

Healthy soil provides interconnected ecosystem services vital for agriculture, environment, and society (Doran and Zeiss, 2000).

#### 1.1. The Five Essential Ecosystem Services

- **Regulating Water:** Soil acts as a reservoir and filter, managing infiltration, storage, and runoff to prevent erosion and flooding.
- **Sustaining Plant and Animal Life:** Provides medium, water, and nutrients for terrestrial food webs.
- **Filtering Pollutants:** Degrades organic/inorganic materials, protecting water quality.
- **Cycling Nutrients:** Microbes decompose matter, making nutrients plant-available.

- **Physical Stability:** Anchors roots and supports infrastructure.

These functions are interdependent; improving one (e.g., nutrient cycling via organic matter) enhances others like water retention.

### 1.2. Agricultural Resilience and Profitability

Soil health reduces costs through efficient nutrient cycling, pest suppression, and improved structure, leading to stable yields and resilience. It minimizes synthetic fertilizer and pesticide needs, boosting profitability.

### 1.3. Defense against Climate Volatility

Soil organic matter (SOM) holds 18-20 times its weight in water; a 1% SOM increase stores 27,000 gallons/acre, aiding drought resilience (Lehmann et al., 2020). Stable aggregates improve infiltration, reducing runoff and erosion during heavy rains.

### 1.4. Carbon Connection: Mitigating Climate Change

Soil holds more carbon than atmosphere and plants combined. Health practices sequester CO<sub>2</sub> via photosynthesis and root exudates, turning agriculture into a carbon sink. No-till reduces emissions by minimizing disturbance.

## 2. A SYSTEMS APPROACH TO SOIL HEALTH MANAGEMENT

### 2.1. The Four Foundational Principles (NRCS, 2021)

- **Minimize Disturbance:** Reduce physical (tillage), chemical (overuse of inputs), and biological disruptions to protect structure and habitat.
- **Maximize Soil Cover:** Use plants or residue to prevent erosion, retain moisture, and moderate temperature.
- **Maximize Biodiversity:** Diverse crops, cover mixes, and livestock support varied microbes, breaking pest cycles.
- **Maximize Continuous Living Roots:** Provide constant carbon exudates to feed soil biology, avoiding fallow periods.

### 2.2. Practitioner’s Toolkit

Practice	Primary Principle(s)	Key Mechanisms	Primary Benefits
Conservation Tillage	Minimize Disturbance	Preserves aggregates; leaves residue.	Reduced erosion; better water retention; lower costs; builds SOM.

Practice	Primary Principle(s)	Key Mechanisms	Primary Benefits
Cover Cropping	Maximize Cover/Roots/Biodiversity	Protects surface; roots feed microbes; adds biomass.	Weed suppression; nutrient retention; improved SOM/water capacity
Diverse Rotations	Maximize Biodiversity	Varies roots/exudates; disrupts pests.	Enhanced cycling; pest suppression; resilience.
Livestock Integration	Maximize Biodiversity	Recycles nutrients; stimulates growth.	Tight nutrient cycles; improved SOM/structure.
Organic Amendments	Maximize Biodiversity	Provides carbon/nutrients/microbes.	Better fertility/structure; water capacity.

**Table 1: Soil Health Management Practices and Functions**

### 3. MEASURING WHAT MATTERS: A GUIDE TO SOIL HEALTH ASSESSMENT

#### 3.1. The Triad of Indicators

- **Physical:** Aggregate stability (resists erosion), infiltration rate (water entry speed), bulk density (compaction level), topsoil depth.
- **Chemical:** Soil pH (6.0-7.5 optimal for nutrient availability), electrical conductivity (salinity), SOM/SOC (key for fertility), nutrient levels.
- **Biological:** Earthworm counts (structure/nutrient cycling), soil respiration (microbial activity), microbial biomass, active carbon (POxC; quick response to changes).

#### 3.2. In-Field and Laboratory Analysis

- **In-Field:** Qualitative tests like VESS (structure evaluation), slake test (aggregate stability), earthworm observation.
- **Laboratory:** Quantitative metrics for baselines and tracking.

Category	Indicator	What It Measures	Method(s)	Interpretation
Physical	Aggregate Stability	Resistance to erosion.	Slake test; water-sieving.	High = good structure, low erosion.
	Infiltration Rate	Water entry speed.	Ring infiltrometer.	High = good porosity, reduced runoff.
	Bulk Density	Compaction degree.	Core analysis.	Low = ample space for roots/air/water.

Category	Indicator	What It Measures	Method(s)	Interpretation
Chemical	Soil pH	Acidity/alkalinity.	pH meter.	6.0-7.5 maximizes nutrient availability.
	SOM	Carbon-based component.	Loss-on-ignition.	Higher = better fertility/water retention.
Biological	Earthworm Count	Abundance of engineers.	Shovel test.	High = good aeration/food web.
	Soil Respiration	Microbial activity.	CO <sub>2</sub> measurement.	High = active community.
	Active Carbon (PO <sub>x</sub> C)	Available food for microbes.	Permanganate reaction.	Early indicator of management changes.

**Table 2: The Triad of Indicators**

#### 4. OVERCOMING BARRIERS TO WIDESPREAD ADOPTION

##### 4.1. Economics of Transition

- Upfront costs: Equipment for no-till, cover crop seeds, learning time.
- Delayed ROI: 3-5 years to profitability; initial yield dips.
- Practice risks: Cooler soils in no-till, mismanaged covers competing for resources.

##### 4.2. Systemic Hurdles

- Knowledge gaps: Limited localized training/extension services.
- Policy disincentives: Crop insurance discourages covers; no payment for externalities like carbon sequestration.
- Social/ structural: Short-term land leases deter investments; community norms resist change.

#### 5. EMERGING FRONTIERS AND CRITICAL PERSPECTIVES

##### 5.1. Critical Analysis of "Regenerative Agriculture"

Builds on soil health for restoration but lacks regulation, risking greenwashing. Critics note "regenerative illusion" from off-farm inputs and unproven sequestration claims (Giller *et al.*, 2021).

## 5.2. Technological Edge: Precision Agriculture

Uses GPS, sensors, VRT for site-specific management, e.g., targeted cover cropping. Integrates with holistic principles for efficiency.

## 5.3. Future Directions

- Soil-human health links: Nutrient bioavailability, gut microbiome.
- Standardization: Validate indicators; long-term research sites.
- Transdisciplinary integration: Collaborate across fields.

## CONCLUSION: SYNTHESIZING SCIENCE AND PRACTICE FOR A RESILIENT FUTURE

Soil health is foundational for productivity, resilience, and sustainability. Guided by four principles and practices, it yields interconnected benefits like cost savings, water management, and carbon sequestration. Overcoming barriers requires supportive policies, incentives, and education. Integrating technology and research will advance soil health, ensuring agriculture nourishes populations while regenerating the planet.

## REFERENCES

- NRCS. (2021). Unlock the Secrets in the Soil - Principles for High Functioning Soils. U.S. Department of Agriculture. <https://www.nrcs.usda.gov/sites/default/files/2022-12/NRCS-Principles-for-High-Functioning-Soils-Factsheet-2021-English.pdf>
- Doran, J. W., & Zeiss, M. R. (2000). Soil health and sustainability: managing the biotic component of soil quality. *Applied Soil Ecology*, 15(1), 3-11. <https://pmc.ncbi.nlm.nih.gov/articles/PMC2610104/>
- Lehmann, J., et al. (2020). The concept and future prospects of soil health. *Nature Reviews Earth & Environment*, 1(10), 544-553. <https://pmc.ncbi.nlm.nih.gov/articles/PMC7116140/>
- Bünemann, E. K., et al. (2018). Soil quality – A critical review. *Soil Biology and Biochemistry*, 120, 105-125.
- Newton, P., et al. (2020). What is regenerative agriculture? A review of scholar and practitioner definitions based on processes and outcomes. *Frontiers in Sustainable Food Systems*, 4, 194.
- Giller, K. E., et al. (2021). Regenerative agriculture: An agronomic perspective. *Outlook on Agriculture*, 50(1), 13-25.

## THE EFFECTS OF INTERMITTENT FASTING ON METABOLISM

Nallala Srinija<sup>1</sup> and Hema Deupa<sup>2\*</sup>

M.Sc. Scholar<sup>1</sup>, Research Scholar<sup>2\*</sup>

<sup>1,2</sup>Department of Food Nutrition, Babasaheb Bhimrao Ambedkar University, Lucknow – 226025,  
Uttar Pradesh, India

Email- [hema.rs.fn@bbau.ac.in](mailto:hema.rs.fn@bbau.ac.in)

**Article ID: 11004**

---

### INTRODUCTION

Intermittent fasting, a dietary pattern that involves alternating periods of fasting and eating, has gained significant attention in recent years. Beyond its potential for weight loss, intermittent fasting has also been studied for its impact on metabolism. This practice can trigger various metabolic responses, influencing how the body processes energy and regulates hormones. Intermittent fasting has gained popularity globally, with Western countries leading the trend. While less prevalent in Asia, it's gaining traction, especially in countries like Japan and South Korea. India, with its rich cultural heritage of religious fasting, has embraced modern intermittent fasting for weight loss and health benefits. Obesity and metabolic syndrome (MetS) are escalating global health crises, characterized by a cluster of conditions that significantly increase the risk of cardiovascular disease, type 2 diabetes, and other chronic illnesses. To address these pressing challenges, researchers and healthcare professionals have explored innovative approaches, including dietary interventions.

Intermittent fasting (IF), a dietary pattern involving cyclical periods of abstaining from food and drink, has emerged as a promising strategy. While often associated with weight loss, IF encompasses a broader range of dietary patterns with potential benefits beyond weight management.[1]

Throughout human evolution, physiological adaptations such as ability for energy storage and the flexibility of metabolism in relation to food supply were essential for withstanding periodic food shortages. Numerous case studies that show how western lifestyles have been adapted seem to point to obesity as an attribute of modernization [2, 3]. Over the last ten to fifteen years, intermittent fasting (IF) has gained popularity as an unusual strategy that goes beyond calorie restriction (CR) to potentially lower body weight and enhance metabolic health. Regarding feed-and-fast cycles, meal timing, and calorie intake, there are several IF regimens [4, 5]. The public has access to a wealth of information about different types of intermittent fasting and their alleged health benefits; in example, a search for "diet fasting intermittent alternate day" on the internet in October 2016 produced more than 210,000 results. Conversely, there is a shortage of data supporting intermittent fasting that may

be utilized to inform public health practice recommendations. Periods of voluntarily abstaining from food and liquids, or intermittent fasting, are an age-old practice that people all over the world still adhere to in various forms [6]. The data supporting the health advantages of intermittent fasting is compiled in this review, which also gives an overview of types of intermittent fasting regimens [Table1]. The primary goal of research on intermittent fasting (IF) and metabolic health is to investigate its potential benefits in improving overall health and well-being.

## TYPES OF INTERMITTENT FASTING REGIMENS

### *Alternate Day Fasting*

It involves alternating days of unrestricted eating with fasting days that include a single meal containing about a quarter of the person's daily calorie needs. This modified fasting approach can vary in duration depending on individual schedules. The fasting period with the small meal can last from 30 to 40 hours. The timing of meals can affect the duration of fasting periods.[7]. It has also been demonstrated that fasting on alternate days can effectively reduce a number of cardiovascular disease risk factors. Reductions in low-density lipoprotein (LDL) cholesterol, triglycerides, and total cholesterol have been noted, though not always. Two studies [6,8] found increases in high-density lipoprotein (HDL); however, one research only found increases in women and did not offer quantitative data. There was no difference in HDL concentrations detected in most investigations. Increasing the size of LDL particles may be considered a way to lower the risk of cardiovascular disease, as small LDL particles have been linked to an elevated risk for the condition. Increased LDL particle size was observed in participants who adhered to the fasting procedure in many alternate-day fasting investigations. [7,8,9].

### *Modified fasting regimens*

Energy consumption on regularly scheduled fasting days is often restricted to 20–25% of energy needs, according to modified fasting regimens. In these investigations, periods of extremely restricted energy intake—as opposed to times when no energy is consumed—are referred to as fasting. This kind of plan, also known as intermittent energy restriction, serves as the foundation for the well-known 5:2 diet, which calls for unrestricted eating on the other 5 days of the week and energy restriction on the other 2 non-consecutive days [10]. Mouse studies on the effects of modified alternate-day fasting have been conducted by Varady et al. [11]. In a study that compared 85% dietary restriction on alternate fasting days to ad libitum chow, the group that experienced energy

restriction showed increases in adiponectin and lower levels of visceral fat, resistin, and leptin. Analogous investigations carried out by this team also discovered that similar fasting schedules seem to lower insulin-like growth factor 1 levels, adipocyte size, and cell proliferation in mice [6].

Findings from the small number of modified fasting regimen intervention trials indicate that weight loss is achieved with these eating patterns, whereas glucoregulatory indicators, lipids, and inflammatory markers show modest to mixed effects.

### ***Time restricted feeding (TRF)***

Time-restricted feeding is a dietary approach that involves limiting your eating to a specific window of time each day. This means that you fast for a certain number of hours and then eat all of your meals within a designated window. One of the most popular TRF methods is the 16:8 method. In the 16:8 method, you fast for 16 hours and then eat all of your meals within an 8-hour window. The TRF can offer various health benefits, including weight loss, improved blood sugar control, and reduced inflammation. By extending your fasting periods, you allow your body to enter a metabolic state called autophagy, where it repairs damaged cells and tissues. The common 16-hour fasting to 8-hour feeding pattern has not been the subject of any studies, but because of the length of the feeding period, it can be considered a more cautious time-restricted feeding strategy. Compared to other intermittent fasting regimens, the food schedule is far more akin to a regular eating pattern. Since this eating pattern roughly equates to skipping breakfast and not eating after dinner every day, many people even unknowingly follow it.

### ***Religious fasting regimens***

Religious fasting regimens are practices within various faiths that involve abstaining from food or drink for a specific period of time. These regimens often hold significant spiritual or symbolic meaning, and their observance can vary widely across different religions and cultures. While the exact rules and practices may differ, the underlying purpose often involves self-discipline, spiritual purification, or seeking a closer connection with a higher power.

- 1) ***Ramadan-*** is a religious fasting regimen observed by Muslims worldwide. During this holy month, which lasts for 29 or 30 days, Muslims abstain from food and drink from dawn until dusk. The fast is broken at dusk with a meal called *iftar*, followed by a light meal called *suhoor* before

dawn. Ramadan is a time for spiritual reflection, prayer, and increased charity. It is believed to foster a sense of community and empathy among Muslims.

- 2) **Hindu fasting-** is a common practice in Hinduism, often undertaken for religious, spiritual, or health reasons. It involves abstaining from food or certain types of food for varying periods.

## HEALTHY ADVANTAGES OF INTERMITTENT FASTING ON METABOLISM

### *Metabolic Switch*

The many IF variations vary in how long the fasting phase lasts, and as a result, in how they affect metabolic function [13]. But they're all connected by the fact that, if IF is maintained for an extended period of time, a process known as "flipping the metabolic switch" is triggered [12]. Depending on the initial hepatic glycogen concentration, the make-up of the last meal, and the quantity of energy expended by the individual throughout the fast, this process takes place 12 to 36 hours after the fasting period starts [12]. Turning on the metabolic switch means that the body will no longer prefer to obtain energy from the breakdown of glycogen into glucose, or glycogenolysis, but rather from lipolysis, which involves using lipids from adipose tissue that has been stored as fat. Following their release, lipids are broken down into free fatty acids (FFAs) and first undergo  $\beta$ -oxidation to become the intermediate stage acetyl CoA, which is then converted into the ketones acetoacetate (AcAc) and  $\beta$ -hydroxybutyrate (BHB) [14].

The metabolic switch's biochemical pathways. Intermittent fasting lowers blood glucose levels and causes fats (triacylglycerols and diacylglycerols) to be converted into free fatty acids (FFAs) through the process of lipolysis. After being transferred to the liver, these lipids undergo  $\beta$ -oxidation, converting into  $\beta$ -hydroxybutyrate (BHB) and acetoacetate (AcAc) via the intermediate steps of acetyl Co Enzyme A and Hydroxymethylglutaryl-Co Enzyme A. Blood carries BHB and AcAc to the brain, where they are subsequently absorbed by neurons. Astrocytes are also able to produce ketones, which may be a significant local supply of beta-hydroxybutyrate (BHB) for neurons in addition to the ketones processed in the liver.

Reduced glucose availability and increased ketones lower the Adenosine monophosphate: Adenosine triphosphate ratio in neurons, activating the kinases AMPK and Calcium/calmodulin-dependent protein kinase II, which in turn induces autophagy through Peroxisome proliferator-activated receptor- $\gamma$  coactivator 1- $\alpha$  [PGC1 $\alpha$ ] and Cyclic AMP-responsive element-binding protein [CREB] activation. Furthermore, during a fast, reduced glucose levels trigger autophagy by reducing mTOR

pathway activity. Additionally, BHB may enhance mitochondrial biogenesis, synaptic plasticity, and cellular stress resistance by upregulating the expression of brain-derived neurotrophic factor (BDNF). Because IF lowers blood levels of circulating insulin, the insulin/IGF signalling pathway protects against oxidative and metabolic stress and improves neuroplasticity. with a few minor changes, taken from.

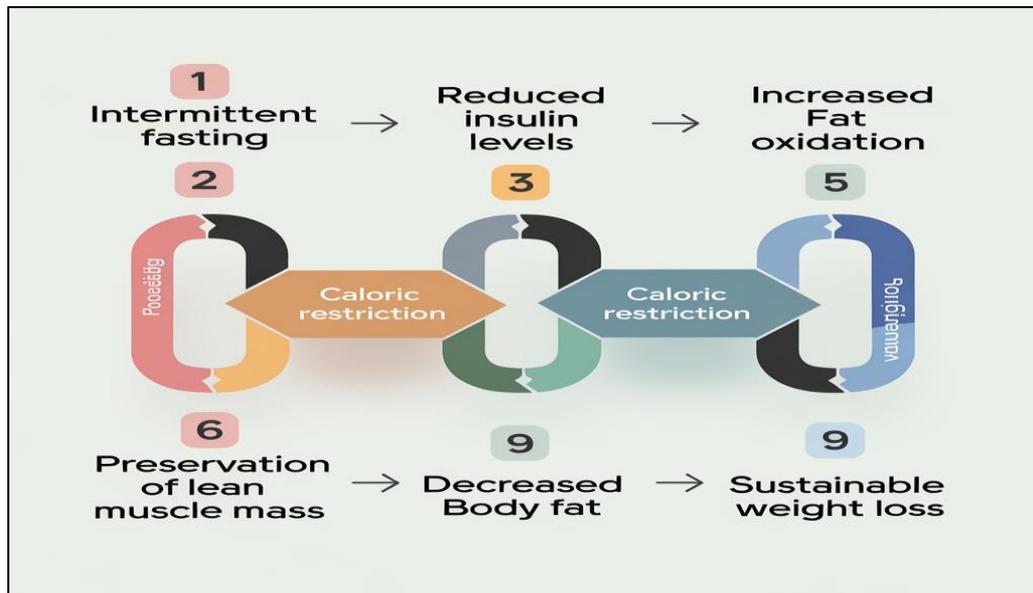
These ketones are especially intriguing for cognition because, when fasting occurs, the brain prefers to run on them. Specifically, ketones regulate transcription factors (e.g., CREB or PGC1 $\alpha$ ) in neurons in addition to their function as an energy source. Brain-derived neurotrophic factors (BDNF) are upregulated as a result of the liver-to-brain transfer of BHB and AcAc, which are then converted back to acetyl CoA and HMG-CoA [14].

By using the mammalian target of rapamycin [mTOR] pathway, neurons can control how much protein is synthesized in response to changes in the availability of nutrients. Protein and lipid synthesis is triggered by the mTOR pathway in a non-fasting state. Conversely, when fasting occurs, the mTOR pathway is less active, which inhibits protein synthesis worldwide and causes autophagy to recycle faulty proteins. Furthermore, as neurodegenerative illnesses progress and age, the body's capacity to withstand oxidative stress—the buildup of damaging free radicals—is largely dependent on autophagy DNA repair, BDNF activation, and antioxidant defenses (molecules that stop free radical oxidation) all improve when the mTOR pathway is inhibited. Furthermore, IF lessens inflammation by lowering blood levels of monocytes, or inflammatory white blood cells, which are the body's overreaction to damage or infection.[15]

By increasing insulin sensitivity, intermittent fasting may potentially have a positive indirect impact on the brain [14]. Patients with diabetes have reduced insulin sensitivity, which affects how well glucose is absorbed by cells, but this deterioration occurs naturally as people age. Because IF lowers blood levels of circulating insulin, insulin receptor sensitivity is increased and the insulin/IGF-1 signalling (IIS) pathway is upregulated [36], which improves neuron uptake and utilization of glucose [14]. Increased neuroplasticity and defense against oxidative stress are linked to upregulated IIS activity, which also lowers the activity of the mTOR pathway

### Weight loss

The **Figure 1** depicts the process of intermittent fasting (IF) and its potential benefits for weight loss. IF involves alternating periods of fasting with periods of eating. This can lead to reduced insulin levels, which in turn promotes increased fat oxidation or burning. Additionally, IF often involves caloric restriction, which can further contribute to weight loss. By combining these factors, IF can help preserve lean muscle mass while decreasing body fat, ultimately leading to sustainable weight loss.



**Figure 1: Shows effect of Intermittent fasting on Weight Loss**

### NEGATIVE EFFECTS OF INTERMITTENT FASTING

Intermittent fasting (IF) can have some side effects, including:

#### *Energy Expenditure*

The circadian clock is shown to control locomotion in animals; mice fed an isocaloric diet for a set amount of time showed enhanced motor coordination at the end of the feeding period [16]. Time-restricted feeding regimens have also been shown to increase locomotion in rats [16] and enhance circadian activity rhythms [16], which are a measure of overall rhythmicity. In their alternate-day fasting study, Hoddy et al. [17] did not find any differences in physical activity as measured by actigraphy at baseline and postintervention. When comparing the 24-hour physical activity of the breakfast-free intervention group to the control group, Chowdhury et al. [18] found no differences.

## *Sleep*

Nighttime eating has been linked in a number of observational studies to shorter sleep duration and lower quality sleep. This can result in insulin resistance and a higher risk of obesity, diabetes, cardiovascular disease, and cancer [19]. In particular, it is theorized that consuming meals at irregular times of day—that is, late at night—causes circadian desynchronization, which in turn disrupts regular sleep cycles. When comparing frequently skipping breakfast (i.e., extending the evening fast) to controls, Chowdhury et al. [18] observed no influence on waking time, sleep duration, or sleep time. As far as we are aware, no other research has specifically looked at the relationships between sleep and intermittent fasting in individuals who live independently.

## CONCLUSION

A lot of interest has been shown in intermittent fasting (IF) as a possible weight-loss and health-promoting strategy. While research has yielded promising results, it's essential to consider both the potential benefits and limitations. On the positive side, IF has been shown to reduce insulin resistance and promote fat loss. Additionally, some studies suggest that IF may have positive effects on cardiovascular health and longevity. However, it's important to note that IF may not be suitable for everyone, and individual responses can vary. Factors such as underlying health conditions, medication use, and personal preferences should be carefully considered before adopting an IF regimen. It's crucial to properly monitor and only precede or follow medical or dietitian recommendations.

## REFERENCES

1. Vasim, I., Majeed, C.N. and DeBoer, M.D., 2022. Intermittent fasting and metabolic health. *Nutrients*, 14(3), p.631.
2. Mattson, M.P., Allison, D.B., Fontana, L., Harvie, M., Longo, V.D., Malaisse, W.J., Mosley, M., Notterpek, L., Ravussin, E., Scheer, F.A. and Seyfried, T.N., 2014. Meal frequency and timing in health and disease. *Proceedings of the National Academy of Sciences*, 111(47), pp.16647-16653.
3. Brown, P.J. and Konner, M., 1987. An anthropological perspective on obesity. *Annals of the New York Academy of Sciences*, 499, pp.29-46.
4. Harris, L., Hamilton, S., Azevedo, L.B., Olajide, J., De Brún, C., Waller, G., Whittaker, V., Sharp, T., Lean, M., Hankey, C. and Ells, L., 2018. Intermittent fasting interventions for treatment of overweight and obesity in adults: a systematic review and meta-analysis. *JBI Evidence Synthesis*, 16(2), pp.507-547.

5. Harris, L., McGarty, A., Hutchison, L., Ells, L. and Hankey, C., 2018. Short-term intermittent energy restriction interventions for weight management: a systematic review and meta-analysis. *Obesity Reviews*, 19(1), pp.1-13.
6. Brongers, H.A. ed., 1977. *Instruction and Interpretation: Studies in Hebrew Language, Palestinian Archaeology and Biblical Exegesis: Papers Read at the Joint British-Dutch Old Testament Conference Held at Louvain, 1976, from 30 August to 2 September* (Vol. 20). Brill Archive.
7. Tinsley, G.M. and La Bounty, P.M., 2015. Effects of intermittent fasting on body composition and clinical health markers in humans. *Nutrition reviews*, 73(10), pp.661-674
8. Heilbronn, L.K., Smith, S.R., Martin, C.K., Anton, S.D. and Ravussin, E., 2005. Alternate-day fasting in nonobese subjects: effects on body weight, body composition, and energy metabolism. *The American journal of clinical nutrition*, 81(1), pp.69-73..
9. Johnson, J.B., Summer, W., Cutler, R.G., Martin, B., Hyun, D.H., Dixit, V.D., Pearson, M., Nassar, M., Tellejohan, R., Maudsley, S. and Carlson, O., 2007. Alternate day calorie restriction improves clinical findings and reduces markers of oxidative stress and inflammation in overweight adults with moderate asthma. *Free Radical Biology and Medicine*, 42(5), pp.665-674
10. Mosley, M. and Spencer, M., 2015. *The FastDiet-revised & updated: lose weight, stay healthy, and live longer with the simple secret of intermittent fasting*. Simon and Schuster.
11. Varady, K.A., Hudak, C.S. and Hellerstein, M.K., 2009. Modified alternate-day fasting and cardioprotection: relation to adipose tissue dynamics and dietary fat intake. *Metabolism*, 58(6), pp.803-811
12. Wilhelmi de Toledo, F., Grundler, F., Sirtori, C.R. and Ruscica, M., 2020. Unravelling the health effects of fasting: a long road from obesity treatment to healthy life span increase and improved cognition. *Annals of medicine*, 52(5), pp.147-161.
13. Di Francesco, A., Di Germanio, C., Bernier, M. and De Cabo, R., 2018. A time to fast. *Science*, 362(6416), pp.770-775.
14. Mattson, M.P., Moehl, K., Ghena, N., Schmaedick, M. and Cheng, A., 2018. Intermittent metabolic switching, neuroplasticity and brain health. *Nature Reviews Neuroscience*, 19(2), pp.81-94
15. Gudden J, Arias Vasquez A, Bloemendaal M. The Effects of Intermittent Fasting on Brain and Cognitive Function. *Nutrients*. 2021; 13(9):3166.
16. Hatori, M., Vollmers, C., Zarrinpar, A., DiTacchio, L., Bushong, E.A., Gill, S., Leblanc, M., Chaix, A., Joens, M., Fitzpatrick, J.A. and Ellisman, M.H., 2012. Time-restricted feeding without reducing caloric intake prevents metabolic diseases in mice fed a high-fat diet. *Cell metabolism*, 15(6), pp.848-860.
17. Hoddy, K.K., Gibbons, C., Kroeger, C.M., Trepanowski, J.F., Barnosky, A., Bhutani, S., Gabel, K., Finlayson, G. and Varady, K.A., 2016. Changes in hunger and fullness in relation to gut peptides before and after 8 weeks of alternate day fasting. *Clinical Nutrition*, 35(6), pp.1380-1385.
19. Patterson, R.E. and Sears, D.D., 2017. Metabolic effects of intermittent fasting. *Annual review of nutrition*, 37(1), pp.371-393.

## Building a Developed India: Agricultural Pathways to Viksit Bharat 2047

<sup>\*1</sup>Hem Prakash Verma <sup>2</sup>Khushi Verma and <sup>3</sup>Eshika Soni

<sup>\*1</sup>Senior Research Fellow, Farmer FIRST Project, ICAR-National Institute of Biotic Stress Management, Raipur (CG)

<sup>2</sup>M.Sc. Scholar, Department of Fruit science, Jawaharlal Nehru Krishi Vishwavidyalaya, Jabalpur (MP)

<sup>3</sup>MSc Scholar, Department of Agricultural Extension Education, Indira Gandhi Krishi Vishwavidyalaya, Raipur (CG)

<sup>\*</sup>Corresponding Author email: [hemverma1996@gmail.com](mailto:hemverma1996@gmail.com)

**Article ID: 11005**

### Abstract

The vision of *Viksit Bharat 2047* represents India's collective aspiration to transform into a fully developed and self-reliant nation by the centenary of independence. Anchored on the pillars of *Yuva (Youth)*, *Garib (Poor)*, *Mahilayen (Women)* and *Annadata (Farmers)*, the initiative focuses on inclusive and sustainable growth. Recent government schemes such as the PM Dhan-Dhaanya Krishi Yojana (PMDDKY), the National Mission on Natural Farming and the Mission for Aatmanirbharta in Pulses aim to strengthen the agricultural foundation of India, enhancing productivity, promoting eco-friendly practices and ensuring income security for farmers. Together, these interventions mark a decisive shift toward self-reliance (*Aatmanirbharta*), climate resilience and equitable prosperity. This article discusses these flagship schemes, their objectives and their role in realizing the vision of *Viksit Bharat* by 2047.

**Key words:** *Viksit Bharat*, PMDDKY, National Mission and Aatmanirbharta.

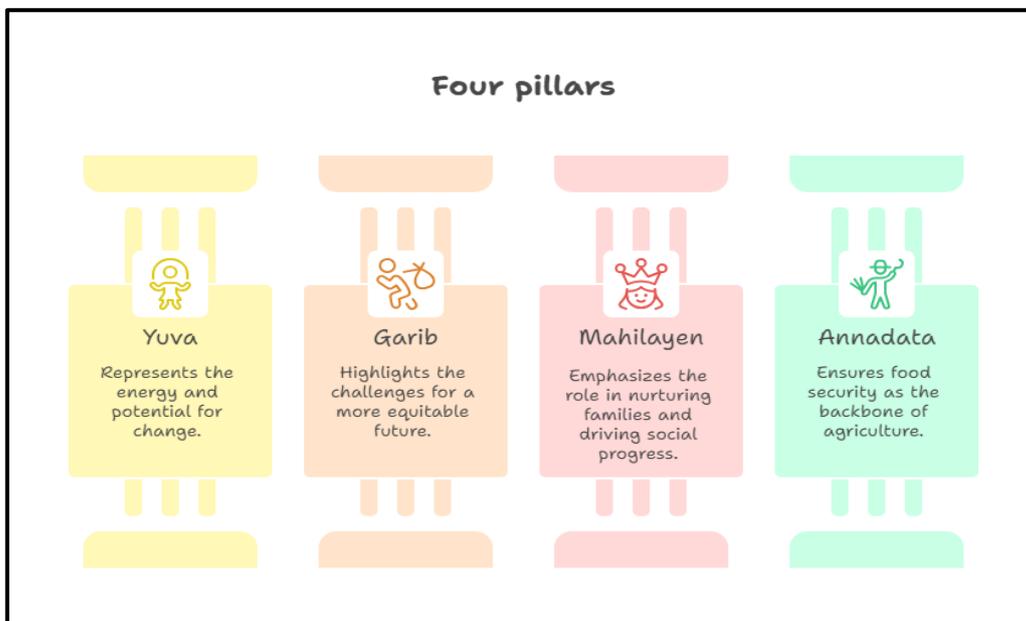
### Introduction

India's journey toward becoming a developed nation is guided by the transformative vision of *Viksit Bharat 2047*, an ambitious roadmap unveiled to commemorate 100 years of independence. The initiative aspires to build a nation characterized by economic strength, technological advancement, infrastructural growth, social inclusivity, and environmental sustainability. The Union Budget 2025-26 provided key directions for implementing this vision, emphasizing the empowerment of youth, women, farmers, and marginalized groups. Agriculture, being the backbone of the Indian economy, remains central to achieving this developmental milestone. Recognizing this, the Government of India has launched several flagship programs to modernize the sector, enhance productivity, and ensure sustainable livelihoods. Among these, the PM Dhan-Dhaanya Krishi Yojana focuses on comprehensive rural agricultural transformation through district-level planning, convergence of schemes, and digital monitoring. The National Mission on Natural Farming promotes chemical-free,

ecosystem-based agriculture, strengthening the link between traditional wisdom and modern practices. Similarly, the Mission for Aatmanirbharta in Pulses aims to achieve self-reliance in pulse production, ensuring nutritional and economic security. Together, these initiatives underscore the government's commitment to transforming Indian agriculture into a resilient, sustainable, and globally competitive sector, contributing to the larger goal of *Viksit Bharat*.

### Viksit Bharat

Viksit Bharat 2047 is the Government of India's visionary mission to transform the nation into a self-reliant and prosperous economy by 2047, marking 100 years of independence. The initiative emphasizes comprehensive progress through economic growth, technological advancement, infrastructure development, social empowerment, and environmental sustainability. Reflecting this vision, the Union Budget 2025-26 presented by Finance Minister Nirmala Sitharaman outlined key priorities aimed at fostering innovation, creating opportunities, and promoting inclusive development in alignment with the goals set out in the interim budget. The vision of Viksit Bharat 2047 is built upon four fundamental pillars e.g. *Yuva* (Youth), *Garib* (Poor), *Mahilayen* (Women) and *Annadata* (Farmers), to ensure empowerment, equity, and sustainable growth for every section of society, paving the way for a truly developed India.



### Major Schemes for Viksit Bharat

#### 1. PM Dhan-Dhaanya Krishi Yojana (PMDDKY)

In a historic step toward strengthening India's agricultural landscape, the Hon'ble Prime Minister has participated in a special Krishi programme at the Indian Agricultural Research Institute (IARI), New Delhi, on 11th October 2025. During this event, the Prime Minister has been launched, inaugurated

and laid the foundation stone and dedicated to the nation a series of major projects and schemes collectively worth over Rs. 42,000 crores, aimed at accelerating growth and innovation in agriculture and allied sectors.

The PM Dhan Dhaanya Krishi Yojana (PMDDKY), an ambitious initiative with an annual outlay of Rs. 24,000 crore for six years. This transformative scheme seeks to revitalize 100 low-performing agricultural districts, turning them into growth engines of rural prosperity. The programme focuses on enhancing agricultural productivity, promoting crop diversification, improving irrigation efficiency, strengthening post-harvest management, and facilitating easier access to agricultural credit. A unique feature of this Yojana is its convergence model, which integrates 36 existing schemes from 11 different ministries to ensure holistic development of agriculture and allied sectors. The initiative aims to benefit around 1.7 crore farmers directly, fostering inclusive and sustainable growth. District-level plans will be prepared by the respective collectors in collaboration with agricultural universities and NITI Aayog, ensuring localized planning and effective implementation. To ensure transparency and accountability, a robust digital ecosystem will be developed, featuring a real-time monitoring dashboard, a farmer-centric mobile application and a district performance ranking system. These digital tools will support data-driven decision-making and improve coordination among implementing agencies.

## **2. National Mission on Natural Farming**

Natural Farming (NF) is a chemical-free, sustainable agricultural approach that integrates livestock (especially local cow breeds) with diversified cropping systems rooted in India's traditional knowledge. Recognizing the interdependence of soil, water, microbes, plants, animals, climate, and human needs, the National Mission on Natural Farming (NMNF), launched in November 2024 as a standalone Centrally Sponsored Scheme, aims to promote ecosystem-based farming practices across 7.5 lakh hectares through 15,000 clusters, with a total outlay of Rs. 2,481 crores to benefit one crore farmers. The mission envisions setting up 10,000 Bio-input Resource Centres (BRC) and has deployed over 70,000 trained Krishi Sakhis to ensure timely input delivery and farmer support. To incentivize adoption, Rs. 4,000 per acre per year is provided for two years, and by July 2025, over 10 lakh farmers had enrolled, 1,100 model farms were established, and 806 training institutes actively engaged in capacity building.

## **3. Mission for Aatmanirbharta in Pulses**

The Mission for Aatmanirbharta in Pulses (Dalhan Aatmanirbharta Mission) with a total outlay of Rs. 11,440 crores for the period 2025-26 to 2030-31. The mission aims to scale up domestic pulses

production to 350 lakh tonnes and expand the cultivation area to 310 lakh hectares by 2030-31. To strengthen farmer confidence and income security, the government has assured 100 percent procurement of key pulses; Tur (Arhar), Urad and Masoor at Minimum Support Prices for four years. The initiative also includes the distribution of 88 lakh free seed kits and 126 lakh quintals of certified seeds, benefiting nearly two crore farmers through improved seed access, assured procurement, and stronger value chain linkages.

**Conclusion:**

The path to *Viksit Bharat 2047* is deeply rooted in strengthening India's agrarian foundation through innovation, inclusivity, and sustainability. The PM Dhan-Dhaanya Krishi Yojana (PMDDKY) addresses structural challenges in agriculture by fostering convergence, decentralization, and accountability, while the National Mission on Natural Farming revives eco-friendly and low-input farming systems aligned with traditional knowledge. Complementing these efforts, the Mission for Aatmanirbharta in Pulses ensures nutritional and economic self-sufficiency through technological intervention, assured procurement, and quality seed distribution. Collectively, these schemes embody the spirit of *Sabka Saath, Sabka Vikas*, enabling rural prosperity and environmental harmony. By empowering farmers, strengthening food systems and promoting sustainable growth, these initiatives lay a solid foundation for a resilient, equitable and developed India, truly realizing the vision of *Viksit Bharat* by 2047.

## The Rise of Precision Agriculture: Farming with Data

Dr. Shashikala Lakra

Teaching Faculty, Department of Agricultural Extension, Mahatma Gandhi University of Horticulture and Forestry Durg, Chhattisgarh

Article ID: 11006

---

### Introduction

Agriculture is undergoing a revolution in the age of digital transformation. Precision agriculture, a fast expanding discipline, is changing how we grow food by using data to inform decisions. The days of farming being based only on tradition and intuition are long gone. The application of innovative technologies and data analysis to improve agricultural operations is known as precision farming or precision agriculture. It involves using sensors, satellites, drones, and GPS-enabled equipment to collect data in real time from fields. Farmers subsequently utilise this information to make more informed choices regarding pest management, fertilisation, irrigation, and planting. The need for effective, resilient agricultural systems is growing as a result of climate change and the world's increasing food demand. Governments, agri-tech companies, and research institutions are making significant investments in precision agriculture with the goal of making it more widely available, more affordable, and more scalable. Precision agriculture may be the key to feeding the world sustainably as growing global food needs and the effects of climate change intensify. Digital agriculture and more efficient use of time and resources could make agriculture more reliable and productive.

### Key Aspects of Precision farming

The precision farming mainly depends on three key aspects. They are:

- 1. Information:** One of the most important components of precision farming is information, which primarily deals with the many aspects of temporal and geographical variability data that are used to inform management decisions.
- 2. Technology:** It includes learning about several facets of crop and land factors through the use of technology such as GPS, GIS, remote sensing, etc.
- 3. Management:** It includes decisions made by management to control variability.

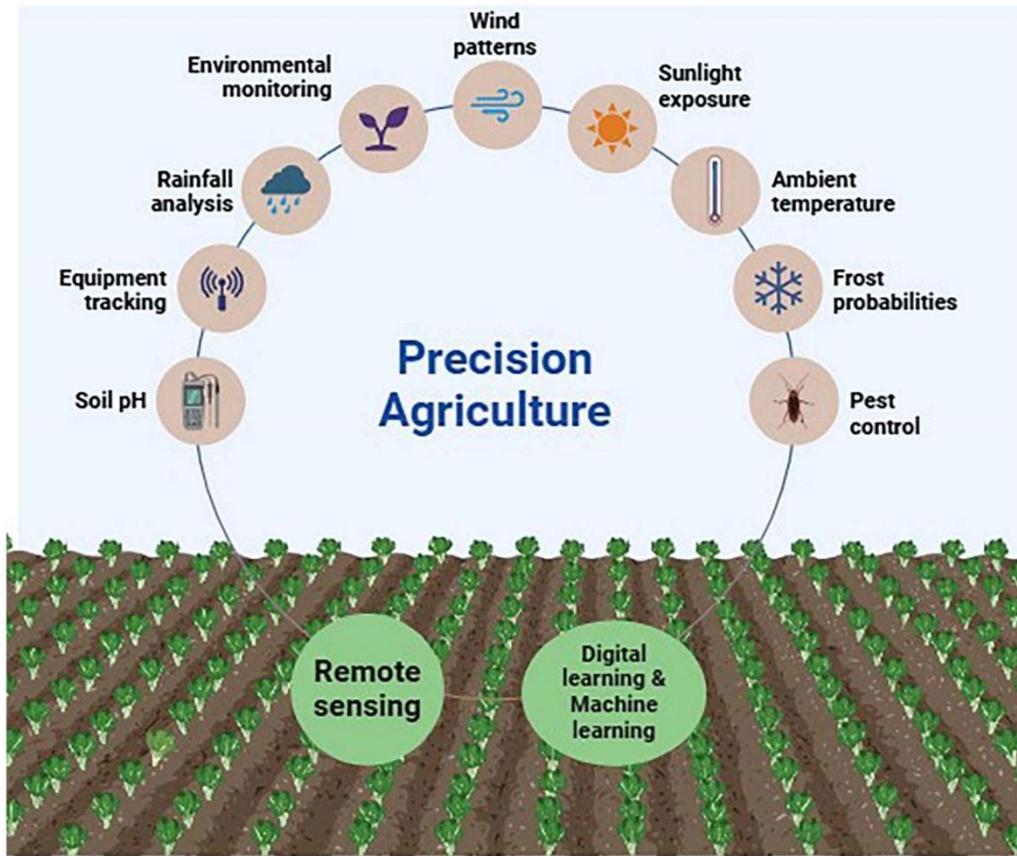
## The Core Technologies Behind Precision Agriculture

- 1. Remote Sensing & Drones:** Farmers are able to keep updated on crop health, soil variance, and moisture levels by using drones and satellites to take overhead photos.
- 2. GPS Technology:** Accurate field mapping made possible by Global Positioning Systems makes it possible to plant, spray, and harvest crops precisely.
- 3. Data Analytics & AI (Artificial Intelligence):** Advanced computer programs examine gathered data to find patterns and suggest plans of action, such when and where to apply fertilizer or irrigation.
- 4. Soil and Crop Sensors:** Real-time measurements of pH, temperature, moisture, and nutrient content are made by in-field sensors, which reduces uncertainty in farming.
- 5. Internet of Things (IoT) Devices & Automation:** Agricultural machinery and sensors are connected via technology, enabling real-time automated modifications in response to environmental changes. Precision agriculture enables the automation of data gathering and processing for accuracy to make the best possible decision.

## Why is this important for farmers?

Precision farming is important for farmers because it uses modern technology to increase efficiency, reduce costs, and maximize yields. By providing a detailed, data-driven understanding of their fields, it allows farmers to move away from uniform, whole-field treatments and apply inputs with greater accuracy. Now a days modern farming involves more than just producing crops; it also involves doing it more efficiently. Precision farming provides a number of important advantages:

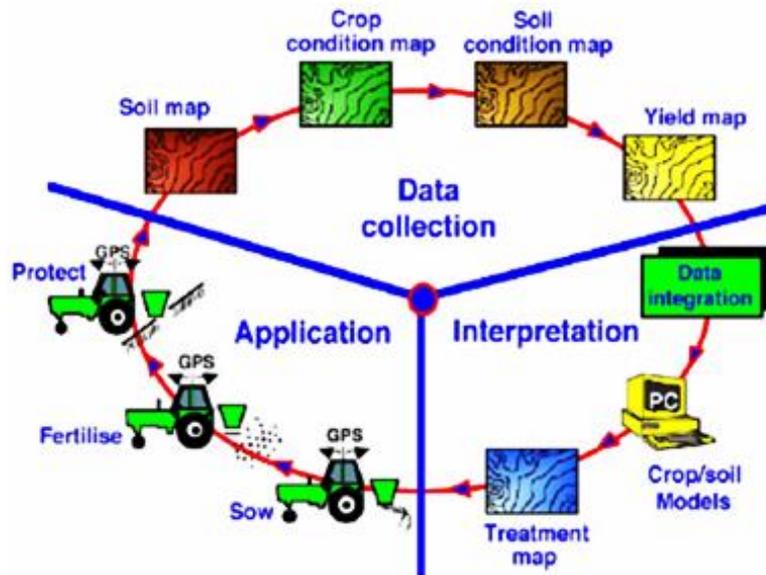
- **Increased Yields:** Crop performance is enhanced when water, fertiliser, and pesticides are applied sparingly.
- **Cost Savings:** Overall costs are decreased when fewer resources are used.
- **Environmental Protection:** Better soil management, less chemical use, and less runoff.
- **Risk reduction:** Crop failure can be avoided by identifying issues early.
- **Labour Efficiency:** In areas with a shortage of labour, automated tools are helpful.



**Fig.1: Graphical representation of factors involved in crop model predictor using deep learning and remote sensing**

### Benefits of Precision Agriculture:

- **Increased Crop Yields:** By applying inputs like water, fertilizer, and pesticides only where needed, farmers can significantly improve yields.
- **Cost Efficiency:** Reduced waste leads to lower input costs and more efficient resource use.
- **Environmental Sustainability:** Targeted farming reduces runoff, conserves water, and minimizes the use of chemicals, promoting eco-friendly practices.
- **Risk Management:** Real-time monitoring helps detect and address issues early, reducing the risk of crop loss.
- **Labor Optimization:** Automation and machine learning reduce the reliance on manual labor, addressing workforce shortages in agriculture.



**Fig.2: Precision Agriculture**

### Challenges to adopting precision agriculture:

1. **High Initial Costs:** The initial investment in technology and infrastructure can be a barrier, particularly for small farms. Advanced equipment and software require substantial investment.
2. **Connectivity Issues:** In rural areas, limited internet access can hinder the adoption of cloud-based and IoT systems. Rural areas often lack reliable internet for cloud-based systems.
3. **Data Privacy Concerns:** As with any digital platform, questions around who owns and controls the data are increasingly important. Farmers need clarity on who controls the data collected from their fields. There are concerns about data ownership and cybersecurity.
4. **Digital Skills Gap:** Farmers need to learn how to use and maintain new systems, and the constant evolution of technology requires continuous learning. Not every farmer is tech-savvy, which can slow adoption. Many farmers need training and support to adopt and manage these technologies effectively.
5. **Economic Disparity:** Large corporations may have a significant advantage in adopting these technologies compared to smaller operations.

### Future Scope of Precision Agriculture

The necessity to increase food production sustainably for a growing population while dealing with limitations on resources is driving precision agriculture's promising future in India. Integrating AI, IoT, and robotics for data-driven decision-making presents significant possibilities that can boost

productivity, profitability, and reduce environmental impact. Recent advances in technology will enable personalized crop management, accurate resource application, and the automation of labor-intensive tasks. Compact treatment units are now possible because to the latest advancements in precision application technology, which customises applications to the needs of particular areas. Sensors and computer technology in automated systems of the future will first classify all plants in the field as either crops or weeds and then determine the type of weed. In a variety of sensing contexts, artificial intelligence (A.I.) has recently been applied to accomplish tasks involving detection, control, and/or prediction.

### Conclusion

A paradigm shift in farming from reactive to proactive, from generalised to customised, is embodied by precision agriculture. Farmers can increase productivity, make better decisions, and help create a more secure and sustainable food system by utilising data. The way we farm is being redefined by precision agriculture. Better choices, more efficient use of resources, and a more sustainable future are more important than simply increasing harvests. It will become the new norm in agriculture with the correct backing and investment, so accurate crop management is required that can identify site-specific factors in agricultural lands and modify management plans appropriately with improved decision-making skills. Precision farming is still in its early stages and has a long way to go in many developing countries, including India. The main factor affecting its success is how fast and effectively the data needed to direct the new technology can be found.

### References:

- Adeyemi, A.Y., Anyibama, B., Adebayo, K.B., Kalinzi, J.M., Adeniyi, S.A. and Wada, I. 2024. Precision agriculture: Leveraging data science for sustainable farming. *International Journal of Science and Research Archive*, , 12(02), 1122–1129
- Akhter, R. and Sofi, S.A. 2022. Precision agriculture using IoT data analytics and machine learning. *Journal of King Saud University - Computer and Information Sciences*, 34(8): 5602-5618
- Kumar, R., Kumar, K., Singh, D. and Tomar, K. 2025. Precision Agriculture: Opportunities, Challenges and Future Perception in India. *Archives of Current Research International*. 25(7): 135-144
- Saha, S., Kucher, o. d., Utkina, A. O. and Rebouh, N. Y. 2025. Precision agriculture for improving crop yield predictions: a literature review. *Frontiers in Agronomy*, 7
- Sharma, S. and Angidi, S. 2022. Precision Agriculture and Its Future. *International Journal of Plant & Soil Science* 34(24):200-204

## **Sustainable Agricultural Practices: Farmers' Awareness and the Adoption** **Harivendra Reddy<sup>1</sup>, Arindam Sarkar<sup>1</sup>, Sabita Mondal<sup>2</sup>**

<sup>1</sup>Research Scholars, Department of Agricultural Extension, Uttar Banga Krishi Viswavidyalaya, Pundibari, Coochbehar, WB

<sup>2</sup>Assistant Professor, Department of Agricultural Extension, Uttar Banga Krishi Viswavidyalaya, Pundibari, Coochbehar, WB

Corresponding author's email - [sabidas\\_2007@rediffmail.com](mailto:sabidas_2007@rediffmail.com)

**Article ID: 11007**

Agriculture is crucial for both food security and the economies of rural communities. However, standard agricultural methods significantly harm the environment, leading to pollution, depleted resources, and damaged ecosystems (*Tilman et al., 2002*). This creates a dilemma where essential practices for human survival also degrade the environment. Methods like monocropping, heavy use of chemical fertilizers and pesticides, and poor water management contribute to soil degradation, water contamination, biodiversity loss, and climate change.

Sustainable agriculture offers solutions to reduce these environmental impacts. Sustainable practices include:

- Organic farming
- Agroecology
- Conservation agriculture
- Natural farming

The successful shift to these sustainable practices relies on farmers understanding the pollution issues and knowing about environmentally friendly alternatives. Several studies indicate that farmers are increasingly aware of the environmental impacts of traditional farming, though this awareness varies depending on factors like location, education, and farming experience.

### **Pollution from Chemical Inputs**

Farmers are aware that using too many pesticides and fertilizers can pollute water bodies through runoff, leading to *eutrophication* and health risks (*Zhang et al., 2015*). Despite this awareness, many small-scale farmers continue to use these chemicals because they provide immediate gains in production.

### **Soil Degradation and Biodiversity Loss**

Studies show that farmers notice a decline in soil fertility due to monocropping and excessive chemical use (*Gomiero et al., 2011*). However, the long-term consequences, such as the loss of pollinators and beneficial soil bacteria, are not as well understood.

### **Climate Change Impacts**

While some farmers may not realize how agriculture contributes to greenhouse gas emissions, others connect extreme weather events to unsustainable farming practices (*IPCC, 2019*).

### **Knowledge and Perception of Sustainable Agriculture**

Farmers' decisions to use sustainable agricultural techniques like crop rotation, organic farming, integrated pest management (IPM), and conservation tillage depend on their understanding and perception of the benefits. Organic farmers have reported lower levels of pollution and healthier soil (*Reganold & Wachter, 2016*). However, the broader adoption of organic farming is hindered by misconceptions about lower yields and higher labour costs. Precision farming, which includes GPS-guided technology, helps reduce chemical use in wealthier countries (*Gebbers & Adamchuk, 2010*), but these technologies are often inaccessible to small-scale farmers in poorer nations. Traditional practices, such as natural pest management and intercropping, align with sustainability (*Altieri, 2004*). Reviving these methods through farmer training can further enhance eco-friendly farming.

### **Barriers to Adopting Sustainable Practices**

Several obstacles impede the shift to sustainable agriculture.

- **Economic Constraints:** High initial costs and uncertain returns discourage farmers from changing their methods (*Pannell et al., 2006*).
- **Lack of Access to Information:** Many regions lack adequate extension services, leaving farmers unaware of sustainable alternatives (*Pretty, 2008*).
- **Policy and Market Limitations:** Subsidies for chemical inputs and a lack of premium markets for sustainable products reduce incentives for farmers (*FAO, 2021*).

### **Strategies to Improve Awareness and Adoption**

To encourage sustainable agriculture, several measures can be taken:

- **Farmer Education and Training:** Workshops, demonstration farms, and digital platforms can improve the spread of knowledge.

- **Government Incentives:** Carbon credit schemes and subsidies for organic inputs can promote adoption.
- **Strengthening Local Markets:** Direct connections between farmers and consumers, along with certification programs like organic labelling, can increase profitability.

In conclusion, while farmers are increasingly aware of the pollution caused by agriculture, the adoption of sustainable practices is limited by gaps in knowledge and financial challenges. Policymakers, researchers, and agricultural extension agencies must collaborate to provide the necessary information, funding, and market access. By addressing these issues, the agricultural sector can reduce its environmental impact while maintaining food security.

### References

- Altieri, M. A. (2004). *Agroecology: The science of sustainable agriculture*. CRC Press.
- FAO. (2021). *The State of Food and Agriculture*.
- Gomiero, T., et al. (2011). \*Environmental Impact of Different Agricultural Management Practices
- IPCC. (2019). *Climate Change and Land*
- Pretty, J. (2008). *Agricultural sustainability: Concepts, principles, and evidence*.
- Reganold, J. P., & Wachter, J. M. (2016). *Organic agriculture in the 21st century*
- Tilman, D., et al. (2002). *Agricultural sustainability and intensive production practices*

## India's Rain Opportunity: Harvesting for a Sustainable Future

Pushpita Sarkar<sup>1</sup>, Harivendra Reddy<sup>1</sup>, Arindam Sarkar<sup>1</sup>, Sabita Mondal<sup>2</sup>

<sup>1</sup>Research Scholars, Department of Agricultural Extension, Uttar Banga Krishi Viswavidyalaya, Pundibari, Coochbehar, WB

<sup>2</sup>Assistant Professor, Department of Agricultural Extension, Uttar Banga Krishi Viswavidyalaya, Pundibari, Coochbehar, WB

Corresponding author's email - [sabidas\\_2007@rediffmail.com](mailto:sabidas_2007@rediffmail.com)

Article ID: 11008

India is blessed with the monsoon, but we're not making the most of it. We get plenty of rain, but a lot of it goes to waste because we don't have enough places to store it, and our farms use water inefficiently. Since agriculture uses over 85% of our water, that's a big problem.

But here's the good news: the India Meteorological Department (IMD) says we're likely to have a really good monsoon in 2025. This isn't just a chance to grow more crops; it's a chance to change how we think about water. Instead of relying so much on groundwater, let's focus on collecting and using the rain that falls on our fields.

### The Trouble with Groundwater

Right now, India uses more groundwater than any other country in the world. A whopping 87% of that groundwater goes to farms. This reliance on groundwater is a problem because:

- It's getting depleted (meaning we're using it up faster than it can replenish).
- Pumping it out of the ground is expensive for farmers.
- Our water policies aren't always well-coordinated.

### Why Rainwater Harvesting Makes Sense?

Rainwater harvesting (RWH). It's simple, catch the rain where it falls and store it for later use. Think of traditional methods like ponds, bunds (small dams), and check dams. These are low-cost, local solutions that can:

- Improve the health of our soil.
- Reduce our dependence on groundwater.
- Provide water for both farming and households.

The IMD's forecast isn't just a weather update, it's a wake-up call. We need to empower local communities, put smart water policies in place, and help farmers become rainwater harvesters.

### Key Facts About Water Use in India

- Groundwater King: India is the world's biggest groundwater user, with 87% going to agriculture.

- More Irrigation: Irrigated land grew from 49.3% to 55% between 2016 and 2021.
- Intense Irrigation: Irrigation intensity rose from 144.2% to 154.5% in the same period.
- Groundwater Extraction: We're extracting about 60% of our available groundwater each year.

### **Where Our Irrigation Water Comes From (2023-24 data)**

- Tubewells: 39,134,000 hectares (the biggest source).
- Government Canals: 17,959,000 hectares.
- Other Wells: 10,672,000 hectares.
- Other Sources: 9,147,000 hectares.
- Tanks: 2,235,000 hectares.
- Private Canals: 165,000 hectares.

Different parts of India use different irrigation methods. Wells are common in the northern plains, while canals are important in areas with big rivers. Tanks are more popular in rocky, rain-fed areas.

### **Is Rainwater Harvesting, a Practical Solution?**

We know we have water problems, and rainwater harvesting sounds good in theory. But can it really work in India? Let's look at some facts:

- We Get Enough Rain: The IMD is predicting above-normal rainfall for 2025. In 2024, we got 1206.6 mm of rain, which is plenty if we capture it.
- It Works in Dry Areas: Even in dry states like Rajasthan, people have been using traditional rainwater harvesting for centuries.

### **Traditional Rainwater Harvesting in India**

India has a long history of rainwater harvesting. These systems were designed to provide a reliable water supply, especially for farming.

Rajasthan, for example, is very dry and has limited groundwater. But people there have developed amazing ways to catch and store rainwater, such as:

- Bawaris and Jhalaras (stepwells).
- Talabs, Tankas, Johads, Nadis, Khadins, and Kunds (different types of ponds and tanks).

For Rajasthan's farmers, rainwater harvesting wasn't just a technique; it was a way of life. The benefits are clear:

- It's simple and cheap.

- It's sustainable and adaptable.
- It improves water use, prevents erosion, boosts soil health, reduces floods, and increases crop yields.

### What the Government is Doing

The government is also promoting water efficiency through programs like:

- Pradhan Mantri Krishi Sinchayee Yojana (PMKSY): Aims to get water to every field and improve water use.
- Micro-Irrigation Fund (MIF): Provides loans for innovative irrigation projects.
- Jal Shakti Abhiyan: Catch the Rain: Promotes water conservation and rainwater harvesting.

### The Bottom Line

India gets plenty of rain, but we need to manage it better. Rainwater harvesting is a practical, affordable, and sustainable solution. It can reduce our reliance on groundwater, lower irrigation costs, protect the environment, and make water more available year-round. With a good monsoon expected in 2025, now is the time to focus on rainwater conservation, local storage, and strong community involvement. This can lead to a more secure and sustainable future for our farms and our country.

### References

India Meteorological Department Press Release: Dated: 22th May, 2025

Mandal, P., Mukhopadhyay, A., Mukherjee, S., Mukhopadhyay, U., Bhattacharya, S., Paul, S., 2023. Assessing the suitability of a reservoir site in a water-stressed area in Purulia, India, using AHP-TOPSIS. *Sustain. Water Resour. Manage.* 9 (3). <https://doi.org/10.1007/s40899-023-00852-z>.

Rajasekhar, M., Gadhiraaju, S.R., Kadam, A., Bhagat, V., 2020b. Identification of groundwater recharge-based potential rainwater harvesting sites for sustainable development of a semiarid region of southern India using geospatial, AHP, and SCS-CN approach. *Arab. J. Geosci.* 13 (2). <https://doi.org/10.1007/s12517-019-4996-6>.

Roy, S., Hazra, S., Chanda, A., 2022. Identifying rainwater harvesting structure sites using MCDM-based GIS approach: a mitigation measure for drought in sub-humid red and lateritic zones of West Bengal, India. *Arab. J. Geosci.* 15 (8). <https://doi.org/10.1007/s12517-022-10077-7>

## Use of Endophytic Microbes to Promote Crop Production for Eco-efficient Agriculture

S.K. Rajoriya<sup>1\*</sup>, T.D. Vaishnav<sup>2</sup> & Aakanksha Tiwari<sup>2</sup>

<sup>1</sup>Dept. of MBBT, RNT College of Agriculture, Kapasan, Chittorgrah 312202,

<sup>2</sup>Dept. of Horticulture, RNT College of Agriculture, Kapasan, Chittorgrah 312202,

\*Author for correspondence: [skrajoriya1985@gmail.com](mailto:skrajoriya1985@gmail.com); Cell: 7793072287

Article ID:11009

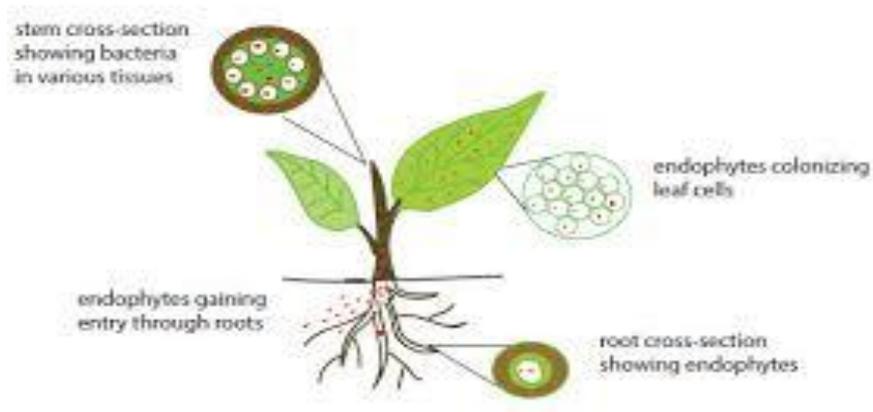
### Introduction:

Agriculture today faces multiple challenges *viz.*, rising input costs, environmental degradation, increasing incidence of pests/diseases and climate-induced abiotic stresses such as drought, salinity, heat, etc. To meet global food demand sustainably, farmers and scientists are looking for approaches that reduce reliance on chemical fertilizers, pesticides and herbicides, while enhancing crop productivity and resilience.

Sustainable agriculture aims to maintain crop productivity while minimizing environmental impacts and preserving natural resources. Among the innovative approaches supporting this vision, **endophytic microbes** have emerged as vital components in improving crop health, productivity, and resilience. Endophytes are microorganisms—mainly **bacteria and fungi**—that reside within plant tissues **without causing any harm**. These hidden allies enhance plant growth, yield, sustainability, confer stress tolerance and play crucial roles in plant defence mechanisms, making them key players in sustainable crop management.

### What Are Endophytic Microbes?

- **Definition:** Microbes (bacteria, fungi and actinomycetes) that live inside plants — roots, leaves, stems, seeds etc. — without causing disease. They can be mutualistic.
- **Diversity:** They belong to many taxa. Among bacteria, common genera include *Bacillus*, *Pseudomonas*, *Rhizobium*, *Burkholderia*, *Klebsiella*, etc. Among fungi, there are *Trichoderma*, *Serendipita indica*, etc.



**Figure:** Endophytic Microbes and their mechanism

### Mechanisms by Which Endophytes Promote Crop Health:

Endophytes can help plants via multiple direct and indirect mechanisms:

#### 1. Nutrient Acquisition & Enhancement

- **Nitrogen fixation** (some bacterial endophytes convert atmospheric  $N_2$  to ammonia usable by plant).
- **Solubilization of nutrients:** phosphate, potassium, zinc etc., which are often present in insoluble forms in soil.
- **Siderophore production:** chelating iron and making it more available to plant, while sometimes restricting pathogen access.

#### 2. Growth Promotion via Phytohormones

- **Production of growth hormones:** auxins (IAA), cytokinins, gibberellins. These influence root system architecture: more branching, more root hairs, better uptake.
- Enzymatic activity that modulates plant's internal signalling (e.g. ACC deaminase to lower ethylene, which reduces plant stress).

#### 3. Stress Tolerance (Abiotic)

- Tolerance to drought, salinity, extremes of temperature and pH variation. Endophytes may help by modulating oxidative stress (controlling reactive oxygen species), producing osmoprotectants, enhancing water uptake, etc.
- These are also tolerance to heavy metals and pollutants. Some endophytes help plant

survive in contaminated soils by sequestration or detoxification.

#### 4. Disease and Pest Suppression (Biotic Stress)

- Production of antimicrobial compounds, enzymes, volatile organic compounds that suppress phytopathogens (fungi, bacteria, viruses).
- **Induced systemic resistance (ISR):** endophytes prime the plant's immune system, so that when pathogens attack, the defense response is stronger/faster.
- Competition for space/nutrients with pathogens.

#### 5. Other Benefits

- Improvement of root system architecture: more roots, deeper roots for water/nutrient uptake.
- Reducing oxidative damage inside plants.

#### Examples of Beneficial Endophytes:

- *Serendipita indica* (synonym *Piriformospora indica*): A fungal root endophyte first isolated from orchid plants in Rajasthan, India. It promotes plant growth, increases salt-stress tolerance, improves resistance to root pathogens, enhances antioxidant capacity.
- *Herbaspirillum seropedicae*: A diazotrophic bacterial endophyte that associates with crops such as maize, rice, sugarcane, etc., improving yields by supplying nitrogen.
- *Paenibacillus polymyxa*: Known for nitrogen fixation and biocontrol, forming biofilms on roots, producing substances that deter pathogens.

#### Application Methods & Management Practices:

To use endophytic microbes effectively in crop health management, appropriate strategies and good practices are needed. These include:

##### 1. Selection of Appropriate Strains

- Screening for local adaptation: endophytes from local soils/plants may perform better.
- Testing for multiple beneficial traits: nutrient mobilization, hormone production, stress tolerance, biocontrol, etc.

##### 2. Inoculation Methods

- Seed treatment: coating seeds with endophyte preparations.
- Soil inoculation: introducing microbes to soils (nurseries, transplanted seedlings).

- Root dips or drenches.
- Sometimes foliar sprays if endophytes can colonize above-ground parts.

### 3. Formulation and Delivery

- Stability: carriers like peat, biochar, compost, or encapsulation to deliver live microbes effectively.
- Ensuring viability under storage/shipping conditions.

### 4. Integration with Agronomic Practices

- Avoiding practices that kill beneficial microbes: overuse of broad-spectrum fungicides, heavy tillage, high salinity or pH extremes, etc.
- Using complementary practices: organic amendments, cover crops, proper rotation.

### 5. Monitoring & Assessment

- Checking colonization success (microscopy, molecular methods).
- Monitoring plant growth, stress markers, disease incidence, yield.

### Challenges and Limitations:

While endophytic microbes hold great promise, there are challenges to practical, large-scale deployment:

- **Variability in field performance:** lab or greenhouse results don't always translate well in field conditions due to environmental fluctuations.
- **Colonization and persistence:** getting the endophytes to establish inside the plant and remain through ontogenesis and under stress is not always easy.
- **Competition with native microbiota:** introduced endophytes must compete with indigenous microbes.
- **Regulation, safety, and consistency:** risk assessment, regulatory approvals, ensuring no unintended effects.
- **Formulation and cost:** making affordable, stable products that farmers can use.

### Recent Advances & Future Prospects:

- Use of **omics** (genomics, metagenomics, transcriptomics, proteomics) to better understand plant–endophyte interactions, to discover novel beneficial strains, and to engineer or select for better performing ones.
- Development of **microbial consortia** (more than one species) rather than single strains, to exploit synergies and cover more functions.

- Breeding or engineering crops that better recruit or partner with beneficial endophytes.
- Tailored endophyte solutions for abiotic stress mitigation (drought, salinity), especially with climate change.
- Policy / extension efforts to make microbial inoculants accessible to farmers.

#### Implications for Sustainable Agriculture:

- **Reduced chemical inputs:** fertilizers, pesticides, and herbicides can be reduced, lowering environmental pollution and costs.
- **Improved resource use efficiency:** better nutrient uptake, water use, etc.
- **Enhanced resilience:** to pests, disease outbreaks, and abiotic stresses.
- **Soil health and biodiversity:** fostering microbial diversity in soils and inside plants helps maintain ecosystem functioning.
- **Food security:** higher, more stable yields under marginal conditions.

#### Case Studies & Practical Examples:

- Use of *Serendipita indica* in multiple crops in India, improving salt stress tolerance and disease resistance.
- Field trials of *Herbaspirillum seropedicae* for maize and rice showing significant yield increases, equivalent in some cases to added nitrogen fertilizer.
- Studies showing that bacterial endophytes in legumes enhance growth, nutrient acquisition, pathogen resistance, etc.

#### Recommendations for Farmers and Researchers:

For those wishing to implement or research this approach:

1. **Start small:** pilot trials in local conditions to test which endophytes work best.
2. **Use local isolates if possible:** adapted to the local soil and climate.
3. **Ensure compatibility:** crop species, soil type, existing microbial communities.
4. **Ensure proper formulation:** live microbes, good shelf life, easy application.
5. **Combine with good practices:** organic matter addition, balanced fertilization, crop rotation.
6. **Monitoring & feedback:** track performance over time; adjust based on observations.

## **Conclusion:**

Endophytic microbes offer a potent tool for improving crop health and management in sustainable agriculture. Through mechanisms such as nutrient acquisition, stress tolerance, disease suppression, and growth promotion, they can help reduce reliance on chemical inputs, enhance resilience, and contribute to long-term soil and ecosystem health. While challenges remain in field consistency, formulation, and regulation, ongoing advances in microbial ecology, biotechnology, and agronomy suggest that endophyte-based solutions will become increasingly viable and important in future agricultural systems.

## **Rice Monoculture in West Bengal: Historical Development, Current Scenario, and Pathways for Sustainability**

**Shreya Das**

Lovely Professional University, Jalandhar, Punjab – 144411

Email: [dshreya904@gmail.com](mailto:dshreya904@gmail.com)

Article ID:11010

---

### **Abstract**

Rice is the most important food crop of West Bengal and also the main food for its people. The state contributes nearly 15% of the total rice produced in India and has earned the name “the rice bowl of the east.” In the past, farmers in West Bengal followed mixed farming, where rice was grown along with pulses, oilseeds, and vegetables. This helped keep the soil fertile and reduced the risk of pests. However, after the Green Revolution, farmers started depending only on rice cultivation. They shifted to high-yielding varieties and chemical fertilizers. Slowly, rice monoculture became common across districts. While this change helped to increase food production and ensured food security for the growing population, it also brought new problems. Soil fertility declined, groundwater levels went down, and pest and disease attacks became frequent. Farmers also lost many of the traditional rice varieties that were rich in taste and quality. This article explains the history of rice monoculture in West Bengal, its present condition, its importance to the economy, and the challenges it creates. It also suggests sustainable methods to continue rice farming in a way that protects soil, water, and biodiversity.

### **Keywords**

Rice Monoculture, West Bengal, Soil Fertility, Water Scarcity, Sustainable Agriculture, Green Revolution

### **Introduction**

West Bengal is the largest producer of rice in India. Rice is grown in almost every district of the state and is the main food for the majority of its people. From daily meals to festivals, rice holds cultural as well as economic importance.

Traditionally, farming in West Bengal was diverse. Farmers cultivated rice during the rainy season, followed by pulses, oilseeds, or vegetables. This diversity kept the soil healthy and reduced pest attacks. But after the Green Revolution in the 1960s, farmers began to grow only rice in large areas.

Government policies such as the Minimum Support Price (MSP) and procurement for the Public Distribution System (PDS) encouraged them further. This trend led to monoculture, where the same crop is grown repeatedly on the same land.

### Historical Development of Rice Monoculture

Before the 1960s, farmers mostly grew indigenous rice varieties that were suited to local soils and weather. These varieties were less demanding and survived even with low inputs. Farmers also followed crop rotation, where rice was grown with pulses and oilseeds. This improved soil fertility naturally.

The Green Revolution brought a major change. New high-yielding varieties like IR8, Swarna, and later hybrid rice gave more output but needed irrigation, fertilizers, and pesticides. Government schemes and markets supported rice cultivation because it was essential for food security. Slowly, farmers reduced other crops and concentrated mainly on rice. Over time, rice monoculture became the dominant system in West Bengal.

### Current Practices in Rice Farming

Rice is cultivated in West Bengal in three main seasons.

**Table 1: Rice Seasons in West Bengal**

Season	Months	Characteristics	Share of Area
Aus	April – August	Short duration, rain-fed, declining area	~5%
Aman	June – December	Main season, rain-fed, largest share	~70%
Boro	January – May	Irrigated, high input, water-intensive	~25%

Aman is the most important season, covering nearly two-thirds of the rice area. Boro rice has increased in recent years due to irrigation but it requires huge amounts of groundwater. Aus rice is slowly disappearing because farmers find it less profitable.

Most farmers depend on chemical fertilizers and pesticides. Modern machines are also used for transplanting and harvesting. While these practices give good yields, they have also increased costs and reduced the natural balance of the soil.

## Economic Significance of Rice

Rice is the backbone of the agricultural economy of West Bengal. It provides employment to millions of small and marginal farmers. The state supplies rice to the Public Distribution System (PDS), which ensures food for poor households. West Bengal also exports aromatic rice like Gobindobhog and Tulaipanji.

However, focusing only on rice has reduced the cultivation of other crops. As a result, the state depends on imports from other regions for pulses and oilseeds. This has reduced dietary diversity and income options for farmers.

## Challenges of Rice Monoculture

### 1. Soil Degradation

Growing rice again and again removes important nutrients such as nitrogen, phosphorus, and potassium from the soil. Farmers use chemical fertilizers, but these cannot replace the natural balance fully. The organic matter of soil has reduced in many districts.

### 2. Water Scarcity

Rice, especially Boro rice, requires a huge quantity of water. On average, it needs 3,000–5,000 liters of water to produce one kilogram of rice. This has led to falling groundwater levels in districts like Nadia, Hooghly, and Murshidabad.

**Table 2: Water Requirement of Rice (Boro Season)**

Item	Amount
Water needed per kg rice	3,000 – 5,000 litres
Groundwater depletion rate	0.5 – 1 metre/year in some districts

### 3. Pests and Diseases

Monoculture creates a favorable condition for pests and diseases. Brown planthopper, stem borer, and sheath blight are common in West Bengal rice fields. Farmers spend heavily on pesticides, but pests often develop resistance.

### 4. Loss of Biodiversity

West Bengal once had thousands of traditional rice varieties, including aromatic and drought-tolerant types. Many of these are now lost because farmers have shifted to HYVs. This has reduced the genetic strength of rice to face climate change.

## 5. Farmer Livelihood Challenges

The cost of cultivation has increased due to fertilizers, pesticides, and irrigation. Small farmers often fall into debt. Climate change, with irregular rainfall and floods, makes them more vulnerable when they depend only on rice.

### Sustainable Alternatives for Rice Systems

- **System of Rice Intensification (SRI):** Uses less water and seeds but increases yield.
- **Alternate Wetting and Drying (AWD):** Saves irrigation water while maintaining productivity.
- **Rice-Fish and Rice-Duck Farming:** Integrates fish or ducks in paddy fields, which helps control pests and adds extra income.
- **Organic Practices:** Use of farmyard manure, green manuring, and biofertilizers can improve soil health.
- **Reviving Traditional Varieties:** Indigenous rice like Tulaipanji and Kalonunia are not only climate-resilient but also have high market demand.
- **Government Support:** Policies should promote pulses and oilseeds in rotation with rice and give incentives for eco-friendly practices.

### Conclusion

Rice monoculture in West Bengal helped the state achieve food security but it also created serious ecological and economic challenges. Soil degradation, groundwater depletion, pest attacks, and biodiversity loss are major concerns. Farmers are under stress due to rising costs and climate risks.

The future lies not in giving up rice but in making rice cultivation sustainable. This can be achieved by adopting water-saving methods, organic practices, and crop diversification within the rice system. Support from government, research institutions, and farmer communities will be essential. By combining modern science with traditional wisdom, West Bengal can secure both food security and environmental health for the future.

### References

Das, A. (2018). Rice Farming in West Bengal: Issues and Prospects. *Indian Journal of Agricultural Economics*.