

## Natural Farming: A Sustainable Paradigm for Ecological Agriculture and Food Security

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### ABSTRACT

*Natural farming represents a transformative paradigm in sustainable agriculture that eliminates synthetic chemical inputs while harnessing indigenous biological processes to restore ecological balance. This review comprehensively examines the principles, practices, and global models of natural farming, including Masanobu Fukuoka's do-nothing farming, Subhash Palekar's Zero Budget Natural Farming (ZBNF), Korean Natural Farming (KNF), and agroecological approaches from Latin America. The paper critically evaluates natural farming's contributions to soil health restoration, biodiversity conservation, carbon sequestration, and water-use efficiency. Furthermore, the review analyses natural farming's role in strengthening food security across its four dimensions: availability, access, utilization, and stability. With over 1.43 million farmers enrolled in India's National Mission on Natural Farming and the Andhra Pradesh Community Managed Natural Farming programme reaching one million smallholders, evidence demonstrates significant potential for scalable adoption. The review identifies challenges including yield variability and knowledge gaps while proposing integrated policy frameworks for mainstreaming natural farming in global food systems.*

**Keywords:** *Natural Farming; Zero Budget Natural Farming; Agroecology; Food Security; Sustainable Agriculture.*

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## INTRODUCTION

The contemporary global food system confronts unprecedented challenges arising from climate change, soil degradation, biodiversity loss, and the unsustainable dependence on agrochemical inputs. The Food and Agriculture Organization (FAO, 2024) reports that approximately 733 million people worldwide face chronic hunger, while intensive conventional farming continues to deplete approximately 24 billion tonnes of fertile topsoil annually. These intertwined crises demand a fundamental rethinking of agricultural paradigms that can simultaneously ensure food security, restore ecological integrity, and support farmer livelihoods.

Natural farming, rooted in the philosophical and practical insights of Masanobu Fukuoka and subsequently advanced by practitioners such as Subhash Palekar in India, offers a compelling alternative to chemical-intensive agriculture. Unlike organic farming, which permits the use of certified external organic inputs, natural farming advocates for the complete elimination of external amendments, instead relying on indigenous microbial processes, mulching, cover cropping, and the integration of livestock by-products to sustain soil fertility and crop productivity (Khadse & Rosset, 2019). The approach embodies the principle of working with nature rather than against it, drawing upon traditional ecological knowledge

refined through generations of agrarian practice.

The resurgence of interest in natural farming has been catalysed by several converging factors: the escalating costs of synthetic fertilizers and pesticides, growing awareness of pesticide residues in food, mounting evidence of pollinator decline linked to agrochemical use, and the demonstrated climate resilience of diversified farming systems (Altieri & Nicholls, 2020). India has emerged as a global leader in institutionalizing natural farming, with the Andhra Pradesh Community Managed Natural Farming (APCNF) programme reaching over one million smallholder farmers and earning the prestigious Gulbenkian Prize for Humanity in 2024 (KfW Development Bank, 2024). The Government of India's National Mission on Natural Farming (NMNF), launched under the broader Paramparagat Krishi Vikas Yojana (PKVY), has enrolled over 1.43 million farmers across 5.45 lakh hectares (Press Information Bureau, 2025).

This review aims to provide a comprehensive analysis of natural farming as a sustainable paradigm for ecological agriculture and food security. It examines the historical evolution, core principles, global models, environmental and socio-economic impacts, the nexus between natural farming and food security, and the challenges and policy imperatives for wider adoption.

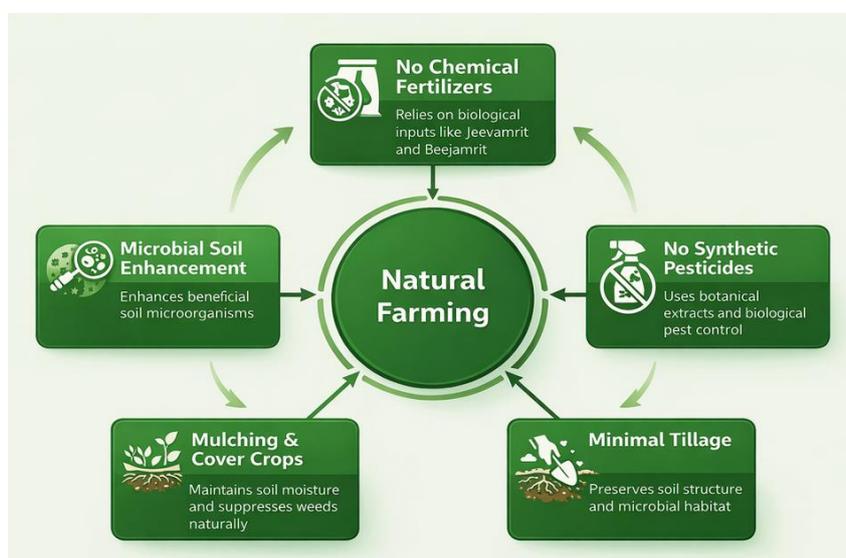


Figure 1: Core Principles of Natural Farming

## 2. Historical Evolution of Natural Farming

The philosophical foundations of natural farming can be traced to the work of Masanobu Fukuoka (1913-2008), a Japanese farmer and philosopher who developed what he termed "do-nothing farming" on his family farmland on the island of Shikoku. Fukuoka, trained as a microbiologist, experienced a pivotal realization that nature, left to itself, maintains perfect balance without human intervention. His seminal work, *The One-Straw Revolution* (1975), articulated four foundational principles: no tillage, no chemical fertilizers or prepared compost, no weeding by tillage or herbicides, and no dependence on chemicals (Fukuoka, 1978). His method involved sowing seed pellets coated in clay, growing rice without flooding fields, and maintaining permanent ground cover with white clover. Remarkably, his yields remained comparable to those of neighbouring conventional farms while continuously improving soil fertility over twenty-five years (Fukuoka, 1978).

In India, the natural farming movement gained momentum through the efforts of Subhash Palekar, a farmer from Maharashtra who developed Zero Budget Natural Farming (ZBNF) in the 1990s as a direct response to the agrarian crisis triggered by the Green Revolution. Palekar observed that the high cost of synthetic inputs was pushing small and marginal farmers into unsustainable debt cycles, leading to widespread rural distress. He formulated ZBNF around four essential pillars: *Beejamrit* (seed treatment with cow dung and urine), *Jeevamrit* (microbial culture for soil enrichment), *Acchadana* (mulching to protect soil and retain moisture), and *Waaphasa* (maintaining optimal soil moisture without irrigation) (Palekar, 2006). The term "zero budget" signifies not that costs are literally zero, but that the need for external credit in cultivation is eliminated (Khadse & Rosset, 2019).

Korean Natural Farming (KNF), developed by Cho Han Kyu, represents another significant regional adaptation that emphasises the cultivation and application of indigenous microorganisms (IMOs), fermented

plant juice (FPJ), and oriental herbal nutrients (OHN) to create self-sustaining farm ecosystems. Meanwhile, biodynamic agriculture, pioneered by Rudolf Steiner in Europe in the 1920s, views the farm as a holistic, self-sufficient organism integrating crop and livestock systems with specialised herbal preparations (Basooriya, 2024). In Latin America, the agroecological movement has incorporated natural farming principles within broader frameworks of food sovereignty, indigenous knowledge systems, and social equity (Altieri & Nicholls, 2020).

## 3. Core Principles and Practices of Natural Farming

Natural farming is distinguished from both conventional and organic farming systems by its fundamental commitment to zero external inputs and its reliance on in situ biological processes. The core principles that underpin natural farming practice can be categorized into five interconnected domains.

### 3.1 Elimination of Synthetic Inputs

The most defining feature of natural farming is the complete avoidance of synthetic chemical fertilizers, pesticides, herbicides, and genetically modified organisms. Unlike organic farming, which permits the application of commercially produced organic manures and certified inputs, natural farming relies exclusively on locally prepared biological amendments derived from indigenous resources such as cow dung, cow urine, pulse flour, jaggery, and beneficial microorganisms (Palekar, 2006). *Jeevamrit*, a cornerstone preparation in ZBNF, functions as a microbial inoculant that enhances soil biological activity by introducing approximately 500 million beneficial microorganisms per millilitre, thereby accelerating nutrient cycling and decomposition processes (Khadse & Rosset, 2019).

### 3.2 Soil Microbial Enhancement

Natural farming places paramount importance on nurturing the soil microbiome as the primary driver of soil fertility. Rather than feeding the plant directly through soluble fertilizers, natural farming focuses on feeding the soil biology, which in turn makes nutrients available to plants through symbiotic relationships. Research demonstrates that

natural farming practices can increase soil microbial biomass carbon by 20-30% compared to conventional systems, enhancing nutrient mineralization, pathogen suppression, and soil aggregate stability (Lori et al., 2017). The application of Beejamrit for seed treatment introduces beneficial rhizosphere microorganisms that protect seeds from soil-borne pathogens while promoting early root development.

### 3.3 Mulching and Soil Cover Management

Acchadana, or mulching, constitutes a critical practice in natural farming, involving the application of crop residues, dried leaves, and other organic matter on the soil surface. This practice serves multiple ecological functions: suppressing weed germination, reducing soil moisture evaporation by up to 30-40%, modulating soil temperature extremes, and providing substrate for decomposer organisms that gradually release nutrients into the soil profile (Sharma et al., 2021). Fukuoka (1978) demonstrated that permanent ground cover with white clover not only fixed atmospheric nitrogen but also created a living mulch that eliminated the need for tillage and herbicide application. Cover cropping with leguminous species such as *Crotalaria juncea* and *Sesbania* spp. further enhances nitrogen fixation and soil organic matter accumulation.

### 3.4 Minimal Tillage and Soil Conservation

Natural farming advocates for minimal or zero tillage to preserve soil structure, protect mycorrhizal fungal networks, maintain

earthworm populations, and prevent disruption of soil aggregates. Conventional tillage has been demonstrated to accelerate soil organic carbon loss, destroy beneficial soil fauna, and increase vulnerability to erosion (Kwiatkowski et al., 2023). By eliminating or minimizing mechanical disturbance, natural farming preserves the soil's natural architecture, enabling better water infiltration, root penetration, and gas exchange. Fukuoka's fields, which had not been ploughed for over twenty-five years, exhibited superior soil structure, water retention capacity, and biological activity compared to conventionally tilled neighbouring farms (Fukuoka, 1978).

### 3.5 Biodiversity Integration and Crop Diversification

Natural farming embraces biodiversity as a functional ecological strategy rather than merely an aesthetic preference. Intercropping, mixed cropping, agroforestry integration, and the maintenance of non-crop vegetation strips create diverse habitats that support natural pest control, pollination services, and nutrient cycling. Altieri and Nicholls (2020) documented that diversified agroecological systems exhibited 30-50% greater natural enemy abundance and significantly reduced pest damage compared to monocultures. The integration of trees, livestock, and aquatic systems within the farm landscape further enhances resource-use efficiency and creates multiple income streams for farming households.

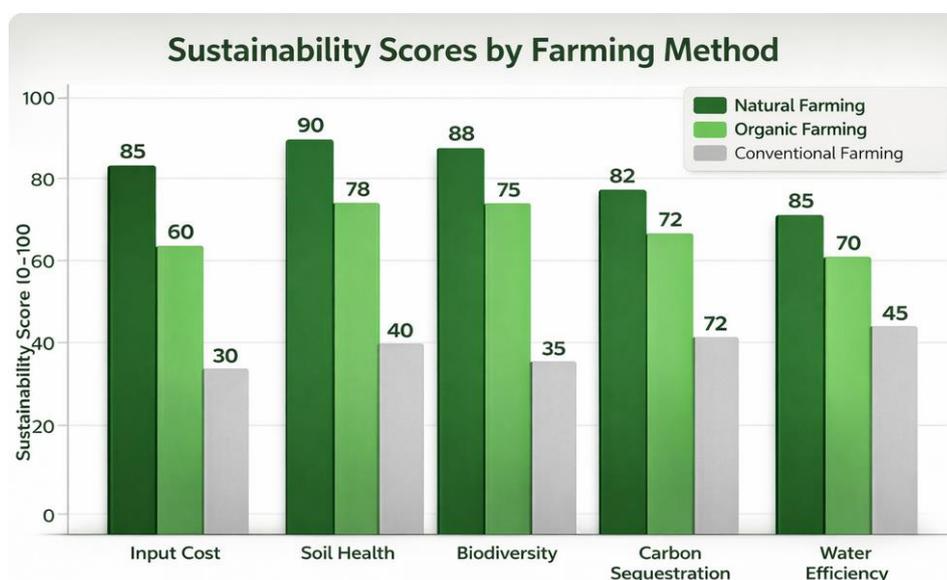


Figure 2: Comparative Analysis of Farming Systems on Sustainability Parameters

#### 4. Global Models of Natural Farming

Natural farming has evolved into diverse regional models, each reflecting unique cultural, ecological, and socio-economic contexts. The convergence of these models

around shared principles of ecological harmony, minimal external inputs, and farmer autonomy demonstrates the universal applicability of natural farming philosophy.

**Table 1: Comparative Analysis of Global Natural Farming Models**

Model	Origin	Key Practice	Primary Focus	Scale of Adoption
Fukuoka Natural Farming	Japan (1975)	Do-nothing farming, clay seed pellets	Minimal intervention, soil ecology	Regional (Japan, SE Asia)
ZBNF (Palekar)	India (1990s)	Jeevamrit, Beejamrit, Acchadana	Zero external cost, soil biology	1.43 million farmers (India)
Korean Natural Farming	South Korea	IMOs, fermented plant juice	Indigenous microorganisms	Asia-Pacific
Biodynamic Agriculture	Europe (1924)	Herbal preparations, cosmic rhythms	Farm as holistic organism	252,000 ha globally
Agroecology	Latin America	Ecosystem design, traditional knowledge	Social equity, food sovereignty	Widespread (Global South)
Permaculture	Australia (1978)	Design principles, zone planning	Permanent agriculture, closed-loop	Global

India's APCNF programme exemplifies successful large-scale implementation of natural farming principles. Launched in 2016 by Rythu Sadhikara Samstha (RySS), the programme has transitioned over one million smallholder farmers, predominantly women, from chemical-intensive agriculture to natural farming across 500,000 hectares. The programme employs a community-managed extension model, with village-level resource

persons (Krishi Sakhis) who practise natural farming themselves and provide peer-to-peer training (KfW Development Bank, 2024). Research from the Centre for Economic and Social Studies (CESS) found that ZBNF practitioners achieved 3.5% to 74.6% lower total costs of cultivation compared to non-ZBNF farmers, while yields were higher in most crops by 0.9% to 23.4% (ICRIER, 2023).



**Figure 3: Global Natural Farming Models and Their Key Features**

## 5. Environmental and Ecological Impacts

### 5.1 Soil Health Restoration

Natural farming has demonstrated profound impacts on soil health restoration. Long-term studies show that elimination of synthetic chemicals combined with continuous organic residue application increases soil organic carbon (SOC) content by 20-45% over five-year periods compared to conventional systems (El-Ghamry et al., 2026). The absence of tillage preserves soil macroaggregates and maintains fungal hyphal networks, particularly arbuscular mycorrhizal fungi that enhance phosphorus uptake efficiency. Soil bulk density decreases under natural farming, indicating improved soil porosity and aeration, while water-holding capacity increases significantly, reducing irrigation requirements by 20-30% in semi-arid regions (Sharma et al., 2021). The microbial diversity in natural farming soils is substantially higher, with research documenting 40-60% greater microbial biomass carbon compared to chemically managed soils (Lori et al., 2017).

### 5.2 Biodiversity Conservation

Natural farming creates habitat mosaics that support significantly higher levels of biodiversity compared to conventional monocultures. Studies document 30-50% greater abundance of natural enemies of crop pests, including predatory arthropods, parasitoid wasps, and insectivorous birds, in diversified natural farming systems (Altieri & Nicholls, 2020). The elimination of synthetic pesticides removes a primary driver of pollinator decline, with natural farming fields showing 2-3 times higher pollinator visitation rates compared to conventional counterparts. Below-ground biodiversity, including earthworm populations, beneficial nematodes, and soil mesofauna, also increases markedly, contributing to enhanced nutrient cycling, soil structure formation, and biological pest suppression (Reiff et al., 2024).

### 5.3 Carbon Sequestration and Climate Change Mitigation

Natural farming contributes to climate change mitigation through multiple pathways. Soil carbon sequestration under natural farming

practices ranges from 0.5 to 1.5 tonnes of carbon per hectare per year, with combined practices of cover cropping and no-tillage achieving rates up to 1.43 tonnes C/ha/year (Bossio et al., 2024). The elimination of synthetic nitrogen fertilizers reduces nitrous oxide (N<sub>2</sub>O) emissions, a greenhouse gas with 298 times the global warming potential of carbon dioxide. Additionally, natural farming reduces the embodied energy associated with fertilizer manufacturing and transportation, further lowering the carbon footprint of agricultural production. El-Ghamry et al. (2026) demonstrated that organic and biodynamic systems achieved soil carbon sequestration values of 6,132 and 5,986 kg/ha respectively after five years, compared to only 4,783 kg/ha under conventional systems.

### 5.4 Water Conservation and Quality

The water conservation benefits of natural farming are multifaceted. Improved soil organic matter content enhances soil water-holding capacity, while mulching reduces evaporative losses by 30-40%. Fukuoka (1978) demonstrated that rice could be successfully grown without continuous flooding, representing a paradigm shift in rice cultivation practices. The elimination of agrochemical runoff prevents eutrophication of water bodies, reduces groundwater contamination, and protects aquatic biodiversity. Studies report that organic and natural farming systems achieve 15-25% higher water-use efficiency compared to conventional systems through improved soil physical properties and reduced water consumption (El-Ghamry et al., 2026).

## 6. Natural Farming and Food Security

The relationship between natural farming and food security is complex and multidimensional. While critics question whether natural farming can sustain yields comparable to intensive conventional agriculture, proponents argue that food security must be evaluated beyond mere production volumes to encompass accessibility, nutritional quality, stability, and sustainability. The FAO defines food security as existing "when all people, at all times, have

physical, social, and economic access to sufficient, safe, and nutritious food that meets their dietary needs and food preferences for an active and healthy life" (FAO, 2024).

### 6.1 Food Availability

Evidence regarding yield performance under natural farming is mixed but increasingly positive. Research from the Centre for Economic and Social Studies indicates that ZBNF yields were higher in most crops by 0.9% to 23.4% compared to conventional practices, with significant cost reductions offsetting any marginal yield variations (ICRIER, 2023). However, field trials by ICAR-IIFSR in north India showed initial yield reductions of up to 40% in the rice-wheat system during the transition period, highlighting the importance of adequate transition support (Down To Earth, 2020). Muller et al. (2017) demonstrated through global modelling that if combined with reductions in food waste and changes in dietary patterns, organic and natural farming systems could feed the global population without requiring additional cropland expansion.

### 6.2 Food Access and Economic Viability

Natural farming significantly enhances food access through dramatic reductions in input costs. ZBNF practitioners report 9% to 36% lower paid-out costs compared to conventional farmers, eliminating the need for expensive purchased inputs such as synthetic fertilizers, pesticides, and hybrid seeds (ICRIER, 2023). This cost reduction is particularly significant for small and marginal farmers who constitute over 86% of India's farming community. By breaking the debt cycle associated with high-input agriculture, natural farming strengthens household food security and rural livelihood resilience. The APCNF programme in Andhra Pradesh has demonstrated rising family incomes among natural farming practitioners, with women's self-help groups serving as the primary implementing mechanism, thereby

enhancing gender equity in agricultural decision-making (KfW Development Bank, 2024).

### 6.3 Nutritional Quality and Food Utilization

Natural farming produces food that is free from synthetic pesticide residues, a growing concern among health-conscious consumers globally. Studies indicate that crops grown under natural and organic systems exhibit higher levels of antioxidants, vitamins, and essential minerals compared to conventionally grown counterparts (Ghalehgolabbehbahani et al., 2024). The crop diversification inherent in natural farming, including the cultivation of traditional, locally-adapted varieties, enhances dietary diversity and nutritional security at the household level. Indigenous crop varieties maintained through natural farming often possess superior nutritional profiles, stress tolerance, and culinary qualities compared to high-yielding commercial varieties.

### 6.4 Food System Stability and Climate Resilience

Natural farming systems demonstrate superior climate resilience compared to chemically-dependent monocultures. Diversified cropping patterns reduce vulnerability to single-crop failure, while improved soil health enhances drought tolerance and flood resilience. The APCNF programme reported that natural farming plots showed greater resilience to the impacts of Cyclone Hudhud and subsequent droughts, with faster recovery and lower yield losses compared to conventional farms (KfW Development Bank, 2024). By reducing dependence on fossil fuel-derived inputs, natural farming also enhances food system stability in the context of volatile energy markets and supply chain disruptions. Gamage et al. (2024) emphasised that sustainable farming practices enhance the capacity for adaptation to climate change, extreme weather events, drought, flooding, and other disasters while progressively improving land and soil quality.



**Figure 4: Natural Farming Contributions to Food Security Dimensions**

## 7. Challenges and Limitations

Despite its promising potential, natural farming faces several significant challenges that must be addressed for wider adoption. The transition period from conventional to natural farming typically spans 2-5 years, during which farmers may experience yield declines of 15-40% before soil biological systems fully recover and stabilize (Down To Earth, 2020). This transition gap poses a significant barrier for resource-poor farmers who cannot afford temporary income losses. ICAR-IIFSR field trials in the rice-wheat system documented 22.6% lower rice costs but 58% lower returns under ZBNF compared to integrated crop management, primarily due to yield reductions during the initial transition years (ICRIER, 2023).

Scalability remains a contested issue. Critics argue that natural farming's labour-intensive practices and lower per-hectare productivity may be insufficient to meet the food demands of a growing global population projected to reach 9.7 billion by 2050 (Muller et al., 2017). The lack of standardized certification frameworks specific to natural farming, unlike the well-established organic certification systems, limits market differentiation and premium pricing opportunities. Furthermore, the scientific

validation of specific natural farming preparations such as Jeevamrit and Beejamrit requires more rigorous, long-term, multi-location field trials to establish evidence-based recommendations across diverse agro-climatic zones (ICRIER, 2023).

Knowledge dissemination and extension support represent additional challenges. Effective natural farming requires deep ecological understanding and farmer skill development that goes beyond simple technology transfer. The limited availability of trained natural farming trainers, inadequate institutional support, and the dominance of conventional agricultural research and extension infrastructure create systemic barriers to scaling. Market access for naturally-farmed produce remains limited in many regions, with the absence of dedicated procurement and marketing channels reducing the economic incentives for transition (Singh & Sharma, 2025).

## 8. Policy Imperatives and Future Directions

Mainstreaming natural farming requires a comprehensive policy framework that addresses transitional support, research priorities, market development, and institutional restructuring. The Government of India's National Mission on Natural Farming (NMNF) represents a significant step, with

plans to cover 1 crore (10 million) farmers across 7.5 lakh (750,000) hectares through Krishi Vigyan Kendra (KVK) networks, bio-input resource centres, and progressive farmer capacity-building programmes (Press Information Bureau, 2023). Financial support of Rs. 12,200 per hectare is provided for cluster formation, product certification, residue analysis, and training.

Future research priorities should include long-term comparative studies across diverse agro-climatic zones, optimization of natural farming preparations for different soil types and cropping systems, integration of precision agriculture technologies with natural farming principles, and development of climate-resilient natural farming packages. The European Union's Farm to Fork Strategy and the Global Alliance for the Future of Food provide international frameworks within which natural farming can be positioned as a viable pathway toward achieving the Sustainable Development Goals, particularly SDG 2 (Zero Hunger), SDG 12 (Responsible Consumption and Production), SDG 13 (Climate Action), and SDG 15 (Life on Land) (United Nations, 2015).

The integration of traditional ecological knowledge with modern scientific tools, such as soil metagenomics, remote sensing for crop monitoring, and blockchain-enabled traceability for natural farming produce, can accelerate adoption while ensuring quality assurance. Establishing dedicated marketing channels, including farmer-producer organizations, direct-to-consumer platforms, and institutional procurement mandates for naturally-farmed produce, will strengthen the economic case for transition (Gawande et al., 2023).

### CONCLUSION

Natural farming represents a scientifically grounded and ecologically sound paradigm that addresses the interconnected challenges of environmental degradation, food insecurity, and rural livelihood crisis confronting global agriculture. By eliminating synthetic chemical inputs and harnessing indigenous biological

processes, natural farming restores soil health, conserves biodiversity, sequesters atmospheric carbon, and enhances water-use efficiency. The global diversity of natural farming models, from Fukuoka's do-nothing farming in Japan to ZBNF in India, Korean Natural Farming, and agroecological approaches in Latin America, demonstrates its universal applicability across diverse agro-ecological and socio-economic contexts.

The evidence reviewed in this paper demonstrates that natural farming can contribute meaningfully to all four dimensions of food security: availability through sustained and diversified production; access through reduced input costs and enhanced farmer incomes; utilization through chemical-free, nutritionally superior produce; and stability through climate-resilient farming systems. The success of India's APCNF programme in transitioning over one million farmers and its recognition with the 2024 Gulbenkian Prize for Humanity provides compelling proof of concept for scalable adoption.

However, realizing the full potential of natural farming requires addressing critical challenges related to transitional yield gaps, scientific validation, extension support, market development, and institutional restructuring. A nuanced policy approach that provides adequate transition support, strengthens farmer knowledge networks, invests in interdisciplinary research, and develops dedicated market infrastructure is essential. Natural farming should not be positioned as a replacement for all forms of agriculture but rather as a powerful complement within a broader spectrum of sustainable agricultural practices. With appropriate policy support, scientific validation, and community-driven implementation, natural farming can play a transformative role in building resilient, equitable, and ecologically sustainable food systems for present and future generations.

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