Available online at www.agrifarming.org

DOI: http://dx.doi.org/10.18782/2582-7146.297

ISSN: 2582 – 7146

Curr. Rese. Agri. Far. (2025) 6(5), 31-38

Review Article

Current Research in Agriculture and Farming

Peer-Reviewed, Refereed, Open Access Journal

Organic and Natural Farming: Current Scientific Perspectives and Future Directions

S. Bharathi[1*], J H Kahodariya[2], Satish Kumar Sharma[3], Naval Kishore Meena[4]
[1]Guest Faculty, Department of School of Agriculture and Animal Sciences,
Gandhigram Rural Institute, Dindigul, Tamil Nadu -624302
[2]Deputy Project Director-ATMA, Botad,
Department of Agricultural Technology Management Agency (ATMA)
[3]Junior Scientist (Plant Biochemistry), Regional Horticulture Research Station, Bhaderwah,
Sher e Kashmir University of Agricultural Sciences and Technology Jammu JKUT 180009
[4]Ph.D. Scholar, Department of Horticulture (Fruit Science), RCA, MPUAT, Udaipur-313001, Rajasthan
*Corresponding Author E-mail: mahibharathi461@gmail.com

Received: 19.07.2025 | Revised: 27.08.2025 | Accepted: 14.09.2025

ABSTRACT

Organic and natural farming systems have gained significant global attention as sustainable alternatives to conventional agriculture. This review critically examines the current scientific evidence on the environmental, agronomic, and socio-economic performance of organic farming and natural farming systems, including Zero Budget Natural Farming (ZBNF). Meta-analyses indicate that organic systems enhance biodiversity by up to 95%, improve soil organic matter by 7%, and reduce energy use by 19%, though yields remain approximately 20% lower per hectare compared to conventional systems. Natural farming, particularly ZBNF pioneered by Subhash Palekar in India, demonstrates promising results in reducing input costs and improving farmer livelihoods. The global organic market reached €145 billion in retail sales by 2024, with farmland expanding to approximately 99 million hectares worldwide. Future directions include the integration of precision agriculture technologies, climate-smart practices, regenerative approaches, and policy harmonization to bridge the yield gap while maximizing environmental co-benefits.

Keywords: *Organic farming, Natural farming, Sustainable agriculture, Biodiversity, Regenerative agriculture.*

INTRODUCTION

The global agricultural system faces an unprecedented challenge: feeding a projected population of 9.7 billion by 2050 while simultaneously addressing environmental degradation, climate change, and the loss of biodiversity (FAO, 2023).

Cite this article: Bharathi, S., Kahodariya, J. H., Sharma, S. K., & Meena, N. K. (2025). Organic and Natural Farming: Current Scientific Perspectives and Future Directions, *Curr. Rese. Agri. Far.* 6(5), 31-38. doi: http://dx.doi.org/10.18782/2582-7146.297

Conventional agriculture, characterized by high-input, monoculture-based production systems, has achieved remarkable productivity gains since the Green Revolution but at considerable ecological cost, including soil degradation, water pollution, greenhouse gas emissions, and the decline of beneficial organisms (Reganold & Wachter, 2016). In this context, organic and natural farming systems have emerged as promising alternatives that seek to balance productivity with ecological sustainability.

Organic farming, as defined by the International Federation of Organic Agriculture Movements (IFOAM), relies on ecological processes, biodiversity, and cycles adapted to local conditions rather than the use of synthetic inputs (Willer et al., 2024). The global organic sector has demonstrated remarkable growth; by 2024, retail sales of organic food and drink reached €145 billion globally, with approximately 98.9 million hectares under organic management and 4.8 million producers worldwide (IFOAM, 2026). Natural farming, particularly Zero Budget Natural Farming (ZBNF) pioneered by Subhash Palekar in India, represents a more radical departure from external input dependence, emphasizing indigenous knowledge, cow-based preparations, and the creation of self-sustaining farm ecosystems (Khadse et al., 2018).

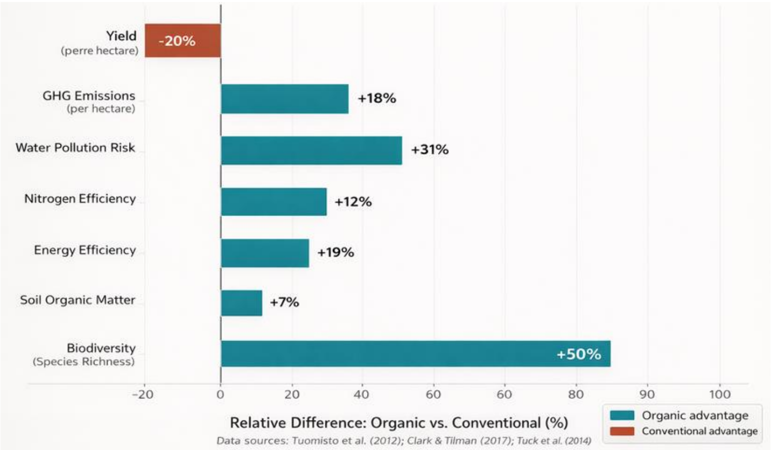
Despite growing adoption, scientific debates persist regarding the scalability, yield potential, and comprehensive environmental benefits of these systems. This review synthesizes current scientific evidence across multiple dimensions—environmental impacts, yield comparisons, soil health, biodiversity, socio-economic outcomes, and emerging technological integrations—to provide an updated assessment of organic and natural farming in the contemporary agricultural landscape.

2. Organic Farming: Environmental and Agronomic Performance

2.1 Biodiversity and Ecosystem Services

One of the most consistently documented benefits of organic farming is its positive impact on biodiversity. A comprehensive meta-analysis evaluating 528 publications found that organic farming significantly increases the mean species number of arable flora by 95%, field birds by 35%, and flower-visiting insects by 23% compared to conventional production systems (Sanders & Heß, 2019). Tuck et al. (2014) corroborated these findings in a meta-analysis of 94 studies, demonstrating that organic farming increased species richness by an average of 30% across diverse taxonomic groups, with the most pronounced benefits observed in intensively managed agricultural landscapes.

The elimination of synthetic pesticides and the promotion of habitat heterogeneity through crop diversification, hedgerow maintenance, and reduced tillage intensity create conditions favorable for both above-ground and below-ground organisms (Bengtsson et al., 2005). A study published in Nature Sustainability found that landscapes with at least 50% organic farming optimize crop yields, soil biodiversity, and key ecosystem functions such as carbon storage, nutrient cycling, and water regulation (University of Alicante, 2026).



Data sources: Tuomisto et al. (2012); Clark & Tilman (2017); Tuck et al. (2014)

Figure 1: Comparative Environmental and Agronomic Performance of Organic vs. Conventional Farming Systems (Data: Tuomisto et al., 2012; Clark & Tilman, 2017)

2.2 Soil Health and Carbon Sequestration

Organic farming practices contribute substantially to improved soil quality. Tuomisto et al. (2012) conducted a meta-analysis of European studies and found that the median soil organic matter (SOM) content was 7% higher in organic farms compared to conventional counterparts, primarily due to 65% higher organic matter inputs through manure and compost applications. The Rodale Institute's Farming Systems Trial, spanning over 40 years of continuous research, demonstrated that organic systems increased SOM levels progressively, leading to improved water-holding capacity, enhanced microbial activity, and greater resilience during drought periods (Rodale Institute, 2022).

In terms of climate impact, organic farms emit an average of 1,082 kg fewer CO_2 equivalents per hectare annually, attributable to higher carbon storage rates and reduced nitrous oxide emissions (Sanders & Heß, 2019). However, when emissions are calculated per unit of product rather than per unit of area, the advantages become less clear due to the yield gap, highlighting the need for yield-improving strategies within organic systems (Clark & Tilman, 2017).

2.3 The Yield Gap and Resource Efficiency

The yield gap remains the most frequently cited limitation of organic farming. A large-scale meta-analysis by Ponisio et al. (2015) reported that organic yields are approximately 19.2% lower than conventional yields on average, though this gap varies significantly by crop type and management practices. Notably, when organic systems employ diversification practices such as multi-cropping and crop rotations, the yield gap narrows to only 8–9% (Ponisio et al., 2015).

The Rodale Institute's long-term trials provide compelling evidence that this gap can close entirely after a transition period. After five years, organic yields equaled conventional yields, and during drought years, organic maize yields were 31% higher than conventional counterparts, owing to improved soil water retention (Rodale Institute, 2022). In terms of resource efficiency, organic systems demonstrated 19% higher energy efficiency and 12% higher nitrogen efficiency compared to conventional agriculture (Sanders & Heß, 2019).

3. Natural Farming: The ZBNF Paradigm

Natural farming represents a distinct philosophical and practical approach within the broader sustainable agriculture movement. Zero Budget Natural Farming (ZBNF), developed by Subhash Palekar in the 1990s in Karnataka, India, promotes an agriculture system entirely free from purchased external inputs, including both synthetic chemicals and commercial organic inputs (Palekar, 2006). The term "Zero Budget" refers to the elimination of all purchased inputs, with farmers relying entirely on on-farm resources and indigenous cow-based preparations.

3.1 Core Principles and Practices

ZBNF is founded on four core pillars (Khadse et al., 2018; & Bharucha et al., 2020):

Figure 2: Conceptual Framework of Natural Farming Principles (ZBNF) (Adapted from: Palekar, 2006; & Khadse et al., 2018)

Jeevamrutha: A fermented microbial culture prepared from cow dung, cow urine, jaggery, pulse flour, and water. Applied to soil, it enhances microbial diversity and nutrient availability. **Bijamrita:** A seed treatment formulation using cow dung, cow urine, lime, and soil to protect seeds and young roots from soil-borne diseases. **Mulching:** Application of crop residues on soil surfaces to conserve moisture, suppress weeds, and build organic matter. **Whapasa:** A concept emphasizing optimal soil moisture conditions where both air and water molecules coexist, reducing the dependence on frequent irrigation (Palekar, 2006).

3.2 Empirical Evidence from India

The largest-scale implementation of ZBNF has occurred in the state of Andhra Pradesh, where the government adopted it as official policy under the Andhra Pradesh Community Managed Natural Farming (APCNF) programme. Field surveys from Karnataka revealed that among 97 farmers surveyed, 78.7% reported improved yields, 93.6% observed better soil conservation, and over 90% experienced reduced farm expenditures and diminished need for credit (Khadse et al., 2018). ZBNF groundnut farmers showed 23% higher yields and paddy farmers 6% higher yields compared to non-ZBNF counterparts (Tripathi et al., 2018).

However, the scientific community remains divided. The National Academy of Agricultural Sciences (NAAS, 2019) cautioned that scaling ZBNF across all production zones could undermine India's agricultural success, arguing that the approach lacks comprehensive scientific validation. Critics note that ZBNF's rejection of all external inputs, including well-validated organic amendments, may limit nutrient replenishment on depleted soils (Flachs, 2020). Nevertheless, ongoing research in Andhra Pradesh and emerging pilot programmes in Himachal Pradesh and Kerala continue to generate evidence on ZBNF's potential and limitations.

4. Global Growth and Market Dynamics

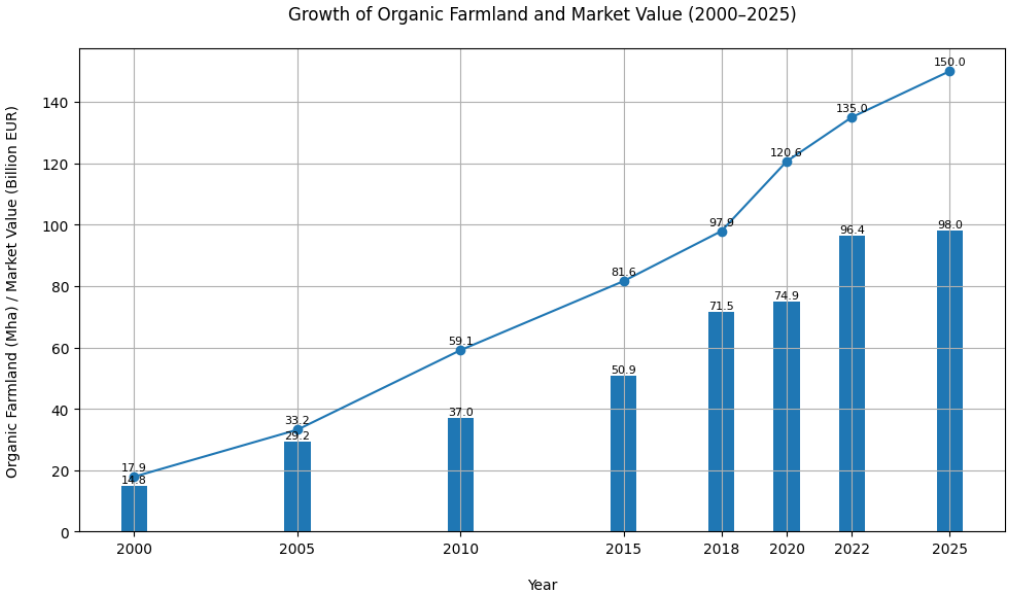


Figure 3: Global Organic Farmland Area and Market Value (2000–2024) (Data: FiBL/IFOAM, 2025; & Willer et al., 2024)

The global organic sector has experienced sustained expansion over the past two decades. From just 14.9 million hectares in 2000, organic farmland grew nearly seven-fold to 98.9 million hectares by 2024 (IFOAM, 2026). Australia leads with 53.0 million hectares, while India has risen to become the country with the highest number of organic producers, approximately 2.5 million (Willer et al., 2024). Global retail sales reached €145.0 billion in 2024, with the United States as the largest single market at €60.4 billion, followed by Germany (€17 billion) and China (€15.5 billion) (IFOAM, 2026). Switzerland recorded the highest per capita organic consumption at €481 per person, with an organic market share of 12.3% of total food sales.

The European Union has set an ambitious target under its Farm to Fork Strategy to achieve 25% of farmland under organic management by 2030, while India's National Mission on Natural Farming aims to expand natural farming practices to 7.5 million hectares (European Commission, 2020; & Government of India, 2023). The Asia-Pacific region is the fastest-growing market, with a projected compound annual growth rate of 12.1%, driven by urbanization, rising incomes, and heightened food safety awareness (Zion Market Research, 2025).

5. Future Directions and Emerging Opportunities

Adapted from: Reganold & Wachter (2016); Eyhorn et al. (2019); FAO (2023).

Figure 4: Future Directions for Organic and Natural Farming Systems (Adapted from: Reganold & Wachter, 2016; & Eyhorn et al., 2019)

5.1 Precision Organic Farming

The integration of precision agriculture technologies with organic farming systems represents one of the most promising pathways for closing the yield gap. Internet of Things (IoT)-enabled sensors for real-time monitoring of soil moisture, pH, temperature, and nutrient levels, combined with artificial intelligence (AI) and machine learning (ML) algorithms for predictive analytics, can optimize resource allocation in organic systems without synthetic inputs (Sishodia et al., 2020). Drone-based remote sensing enables early detection of pest infestations and nutrient deficiencies, allowing timely application of biological control agents and organic amendments (Frontiers in Plant Science, 2025).

5.2 Regenerative Agriculture Convergence

Regenerative agriculture, which extends beyond organic principles to actively restore degraded ecosystems, is emerging as a complementary paradigm. A European

Alliance for Regenerative Agriculture study benchmarking 78 farms across 14 countries found that regenerating farmers achieved yields only 1% lower in kilocalories while using 62% less synthetic nitrogen fertilizer and 76% fewer pesticides per hectare (EARA, 2023). The convergence of organic certification with regenerative practices—including cover cropping, reduced tillage, agroforestry, and integrated livestock management—offers a pathway to higher productivity with enhanced ecological outcomes (Teague et al., 2016).

5.3 Climate Adaptation and Biofortification

Organic and natural farming systems demonstrate inherent resilience to climate variability. During drought conditions, organic maize yields have been documented at 31% higher than conventional yields due to improved soil water-holding capacity (Rodale Institute, 2022). Future research priorities include developing organic-compatible crop varieties through participatory breeding programmes, biofortification of organic crops to enhance micronutrient content, and soil microbiome management to improve nutrient cycling efficiency (Lammerts van Bueren et al., 2011).

5.4 Policy Harmonization and Digital Traceability

The fragmentation of organic standards across countries remains a barrier to trade and consumer trust. Blockchain-enabled traceability systems and harmonized international certification frameworks are emerging as solutions to ensure transparency and reduce certification costs for smallholder producers. The development of participatory guarantee systems (PGS) in countries such as India and Brazil offers cost-effective alternatives to third-party certification, particularly for domestic markets (Eyhorn et al., 2019).

CONCLUSION

The scientific evidence reviewed in this paper demonstrates that organic and natural farming systems offer substantial environmental and socio-economic benefits while presenting specific challenges that require targeted solutions. Organic farming consistently outperforms conventional agriculture in biodiversity conservation (up to 95% higher species richness), soil health (7% higher SOM content), energy efficiency (19% improvement), and reduced environmental pollution (31% lower nitrogen leaching per hectare). The yield gap of approximately 19–20%, though significant, narrows considerably with improved management practices and closes entirely for certain crops after adequate transition periods.

Natural farming, exemplified by ZBNF in India, provides a socially responsive model for reducing farmer indebtedness and production costs, with field evidence showing reduced expenditure for over 90% of adopters and improved yields for a majority. However, the scientific validation of these systems requires more rigorous, long-term, and controlled experimental studies to establish their applicability across diverse agro-climatic zones and cropping systems.

The convergence of organic principles with precision agriculture technologies, regenerative practices, and supportive policy frameworks offers a realistic pathway toward sustainable intensification. As the global organic market surpasses €145 billion and farmland approaches 100 million hectares, the momentum behind these systems is undeniable. Future research must focus on closing the yield gap through technological innovation, breeding climate-resilient organic varieties, optimizing biological nutrient management, and developing inclusive certification systems that empower smallholder farmers in developing nations. The integration of these approaches will be critical for achieving the United Nations Sustainable Development Goals related to zero hunger, climate action, and life on land.

Acknowledgement:

The authors sincerely appreciate the valuable support, guidance, and timely efforts of all co-authors in completing this manuscript successfully.

Funding: NIL.

Conflict of Interest:
The authors declare that no conflicts of interest exist regarding this study.

Author Contribution:
All authors contributed to the preparation, critical revision, and final approval of the manuscript.

REFERENCES

Bengtsson, J., Ahnström, J., & Weibull, A. C. (2005). The effects of organic agriculture on biodiversity and abundance: A meta-analysis. *Journal of Applied Ecology, 42*(2), 261–269.

Bharucha, Z. P., Mitjans, S. B., & Pretty, J. (2020). Towards redesign at scale through zero budget natural farming in Andhra Pradesh, India. *International Journal of Agricultural Sustainability, 18*(1), 1–20.

Clark, M., & Tilman, D. (2017). Comparative analysis of environmental impacts of agricultural production systems, agricultural input efficiency, and food choice. *Environmental Research Letters, 12*(6), 064016.

Eyhorn, F., Muller, A., Reganold, J. P., Frison, E., Herren, H. R., Luttikholt, L., & Smith, P. (2019). Sustainability in global agriculture driven by organic farming. *Nature Sustainability, 2*(4), 253–255.

Flachs, A. (2020). Cultivating knowledge: Biotechnology, sustainability, and the human cost of cotton capitalism in India. *University of Arizona Press*.

Khadse, A., Rosset, P. M., Morales, H., & Ferguson, B. G. (2018). Taking agroecology to scale: The zero budget natural farming peasant movement in Karnataka, India. *The Journal of Peasant Studies, 45*(1), 192–219.

Lammerts van Bueren, E. T., Jones, S. S., Tamm, L., Murphy, K. M., Myers, J. R., Leifert, C., & Messmer, M. M. (2011). The need to breed crop varieties suitable for organic farming, using wheat, tomato and broccoli as examples: A review. *NJAS-Wageningen Journal of Life Sciences, 58*(3–4), 193–205.

Palekar, S. (2006). The philosophy of spiritual farming. *Zero Budget Natural Farming Research,* Development and Extension Movement, Amravati, India.

Ponisio, L. C., M'Gonigle, L. K., Mace, K. C., Palomino, J., de Valpine, P., & Kremen, C. (2015). Diversification practices reduce organic to conventional yield gap. *Proceedings of the Royal Society B: Biological Sciences, 282*(1799), 20141396.

Reganold, J. P., & Wachter, J. M. (2016). Organic agriculture in the twenty-first century. *Nature Plants, 2*(2), 15221.

Sanders, J., & Heß, J. (Eds.). (2019). Leistungen des ökologischen Landbaus für Umwelt und Gesellschaft [Achievements of organic farming for environment and society]. *Thünen Report 65*. Johann Heinrich von Thünen-Institut.

Sishodia, R. P., Ray, R. L., & Singh, S. K. (2020). Applications of remote sensing in precision agriculture: A review. *Remote Sensing, 12*(19), 3136.

Teague, W. R., Apfelbaum, S., Lal, R., Kreuter, U. P., Rowntree, J., Davies, C. A., & Byck, P. (2016). The role of ruminants in reducing agriculture's carbon footprint in North America. *Journal of Soil and Water Conservation, 71*(2), 156–164.

Tripathi, S., Shahidi, T., Nagbhushan, S., & Gupta, A. (2018). Zero budget natural farming for the Sustainable Development Goals: Andhra Pradesh, India. *Council on Energy, Environment and Water*.

Tuck, S. L., Winqvist, C., Mota, F., Ahnström, J., Turnbull, L. A., & Bengtsson, J. (2014). Land-use intensity and the effects of organic farming on biodiversity: A hierarchical meta-analysis. *Journal of Applied Ecology, 51*(3), 746–755.

Tuomisto, H. L., Hodge, I. D., Riordan, P., & Macdonald, D. W. (2012). Does organic farming reduce environmental impacts? A meta-analysis of European research. *Journal of Environmental Management, 112*, 309–320.

Willer, H., Trávníček, J., Meier, C., & Schlatter, B. (Eds.). (2024). The world of organic agriculture: *Statistics and emerging trends 2024*. *FiBL & IFOAM – Organics International*.