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Organic Farming and Its Role in Biodiversity Conservation and Soil Health

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Abstract

Organic farming has emerged as a sustainable agricultural approach that emphasizes ecological balance, biodiversity conservation, and soil health enhancement. By eschewing synthetic fertilizers and pesticides, organic practices rely on natural inputs, crop-livestock and biological processes to maintain soil fertility and control pests. This method fosters a diverse agroecosystem, promoting the proliferation of beneficial organisms and enhancing ecosystem services. One of the key benefits of organic farming is its positive impact on biodiversity. Studies indicate that organic farms often support higher species richness and abundance compared to conventional farms, providing habitats for a variety of flora and fauna. Practices such as crop rotation, intercropping, and the maintenance of hedgerows contribute to this increased biodiversity, which in turn supports pollination, pest control, and nutrient cycling. Soil health is another critical aspect improved by organic farming. The incorporation of organic matter through composting and green manures enhances soil structure, water retention, and microbial activity. These improvements lead to increased nutrient availability and reduced erosion, contributing to long-term soil fertility. Research has shown that organic soils often exhibit higher levels of organic carbon, better aggregation, and greater biological activity than soils under conventional management. Despite these advantages, organic farming faces challenges, including lower initial yields and the need for more labor-intensive practices. However, the long-term environmental benefits, such as improved biodiversity and soil health, make it a viable option for sustainable agriculture. Policy support, research, and education are essential to overcome these challenges and promote the adoption of organic practices. This study on the ecological impacts of organic farming, highlighting its role in promoting biodiversity and enhancing soil health. It underscores the importance of organic agriculture in achieving sustainable food systems and calls for integrated efforts to support its wider implementation.

Keywords: Organic Farming, Biodiversity Conservation, Soil Health, Sustainable Agriculture, Soil Fertility

Introduction

Agriculture has been a cornerstone of human civilization, providing sustenance and shaping societies. However, the intensification of agricultural practices in the 20th century, characterized by the extensive use of synthetic fertilizers, pesticides, and monocultures, has led to significant environmental concerns. These include soil degradation, loss of biodiversity, water contamination, and greenhouse gas emissions. In response to these challenges, organic farming has emerged as a sustainable alternative that emphasizes ecological balance, biodiversity conservation, and soil health (Lynch, 2022). Organic farming is defined by its avoidance of synthetic inputs and its reliance on natural processes and materials. Practices such as crop rotation, composting, green manuring, and biological pest control are central to organic agriculture. These methods aim to enhance soil fertility, promote biodiversity, and reduce environmental pollution. By fostering a holistic approach to farming, organic agriculture seeks to create resilient agroecosystems that are both productive and environmentally sound (Kumar et al., 2025). One of the primary benefits of organic farming is its positive impact on biodiversity. Studies have shown that organic farms often support higher species richness and abundance compared to conventional farms. This is attributed to the diverse habitats and reduced chemical disturbances in organic systems, which provide favorable conditions for various organisms, including pollinators, natural predators, and soil microorganisms (Raveloaritiana & Wanger, 2024). Enhanced biodiversity not only contributes to ecological stability but also supports essential ecosystem services such as pollination and pest regulation. Soil health is another critical aspect improved by organic farming. The incorporation of organic matter through compost and cover crops enhances soil structure, water retention, and nutrient availability. Organic practices also promote a diverse and active soil microbial community, which plays a vital role in nutrient cycling and disease suppression. Healthy soils are more resilient to erosion and climatic extremes, thereby ensuring sustainable crop production (Pazhanivel Koushika et al., 2024).

Despite the evident benefits, organic farming faces challenges, including lower initial yields and the need for more labour-intensive practices. However, the long-term environmental advantages, such as improved biodiversity and soil health, make it a viable option for sustainable agriculture. Policy support, research, and education are essential to overcome these challenges and promote the adoption of organic practices. This paper aims to explore the role of organic farming in biodiversity conservation and soil health enhancement. Furthermore, this study explains the ecological impacts of organic practices, compares them with conventional methods, and discusses the implications for sustainable agriculture. By understanding the benefits and challenges associated with organic farming, stakeholders can make informed decisions to support agricultural systems that are both productive and environmentally responsible.

Principles and Practices of Organic Farming

Organic farming is a holistic and sustainable approach to agriculture that emphasizes ecological balance, biodiversity conservation, and the health of soil, plants, animals, and humans. It avoids the use of synthetic fertilizers, pesticides, genetically modified organisms (GMOs), and relies instead on natural processes and traditional knowledge systems. At the core of organic farming are four guiding principles outlined by the International Federation of Organic Agriculture Movements (IFOAM): health, ecology, fairness, and care (FAO., 2018). The principle of health emphasizes the importance of maintaining and enhancing the well-being of all living organisms, including soil microorganisms, crops, animals, and humans. It seeks to avoid practices that may harm health and instead supports agricultural systems that are preventive and regenerative (Singh et al., 2024). The ecological principle advocates for farming practices that are in harmony with natural ecosystems and cycles. This includes maintaining biodiversity, enhancing soil fertility, and minimizing pollution and resource depletion (Tuck et al., 2014, Reganold, J. P., 2016). Fairness relates to social justice and equity in agricultural practices, ensuring that farmers, workers, and consumers are treated ethically and fairly. Lastly, the principle of care promotes responsible and precautionary measures in farm management to protect current and future generations and preserve the natural environment. In practice, organic farming employs several techniques that support these principles. Soil health is a central focus, with methods such as composting, green manuring, crop rotation, cover cropping, and reduced tillage commonly used to build soil organic matter and support beneficial soil organisms (Lori et al., 2017). Organic systems depend on natural inputs like farmyard manure, vermicompost, and biofertilizers rather than synthetic chemicals. Pest and weed management are achieved through biological controls, trap crops, mechanical weeding, and mulching, avoiding the use of harmful pesticides and herbicides. Biodiversity is further enhanced through practices like agroforestry, polyculture, and the cultivation of indigenous plant varieties, which provide habitats for various species and reduce the risks associated with monoculture (Bertola et al., 2021). Water conservation is also an integral part of organic farming, with techniques such as drip irrigation, mulching, and organic soil amendments improving water use efficiency. Integration of livestock into organic systems allows for nutrient recycling through manure application and supports a closed-loop nutrient system. Organic livestock management also emphasizes animal welfare, banning the use of growth hormones and antibiotics, and ensuring access to pasture and natural feed. Organic certification ensures compliance with specific standards that govern these practices. National and international certification programs, such as the USDA Organic label, the European Union's organic standards, and India's National Programme for Organic Production (NPOP), provide a regulatory framework that promotes transparency, accountability, and consumer confidence. These practices and principles collectively form the foundation of organic farming, offering a sustainable alternative to conventional agriculture and playing a critical role in conserving biodiversity and improving soil health.

Table 1: Organic farming practices supporting biodiversity conservation and soil health.

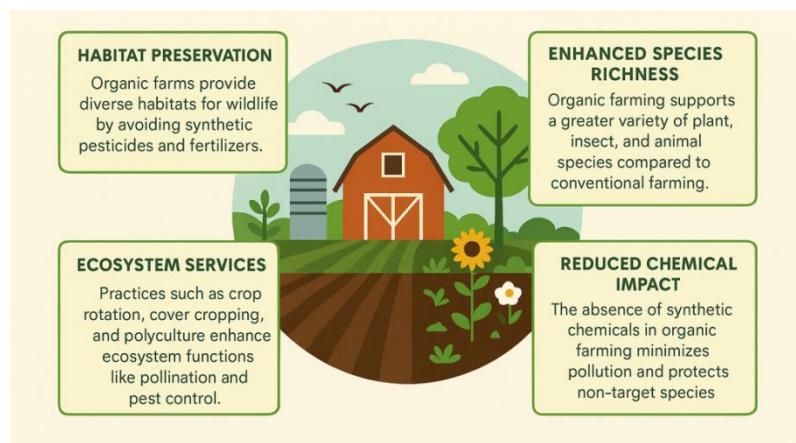
Organic Farming Practices	Example	Biodiversity Conservation	Soil Health
Crop Rotation	Rotating legumes, cereals, and root vegetables	Enhances agrobiodiversity by supporting various plant species	Breaks pest cycles, enhances nutrient balance
Use of Organic Fertilizers	Applying compost, green manure, or animal manure	Supports microbial diversity and soil fauna	Improves soil structure and organic matter content
Intercropping	Planting maize with beans or other legumes	Promotes habitat heterogeneity for insects and pollinators	Increases nutrient cycling and reduces erosion
Cover Cropping	Planting clover or ryegrass in off-season	Provides habitats for beneficial insects and ground-nesting birds	Prevents erosion, fixes nitrogen, and improves moisture retention
Biological Pest Control	Introducing ladybugs to control aphids	Protects non-target species and maintains ecological balance	Reduces chemical residues that can affect soil organisms
Reduced Tillage	Minimal soil disturbance with direct seeding	Preserves soil-dwelling organisms and nesting areas	Enhances soil structure and reduces erosion
Use of Heirloom and Native Seeds	Planting traditional or locally adapted varieties	Conserves genetic diversity and resilience	Enhances crop adaptation to local soil conditions

Agroforestry	Integrating trees like neem or moringa into crop fields	Creates multi-layered habitats for wildlife	Improves nutrient cycling and prevents land degradation
Organic Mulching	Applying straw or leaves as mulch	Provides shelter for invertebrates and ground beetles	Regulates soil temperature, retains moisture, and reduces compaction
Buffer Zones and Wild Margins	Maintaining uncultivated borders with native vegetation	Acts as refuge for pollinators and natural enemies of pests	Prevents runoff and promotes natural soil filtration

Organic Farming and Biodiversity Conservation

Organic farming plays a pivotal role in conserving biodiversity by fostering ecosystems that support a wide array of plant and animal species. By eschewing synthetic chemicals and embracing natural agricultural practices, organic farming enhances habitat diversity, promotes ecological balance, and sustains vital ecosystem services.

Figure 1: Role of organic farming in biodiversity conservation.



1. On-Farm Biodiversity

Organic farms generally maintain higher levels of plant, insect, bird, and microbial diversity compared to conventional farms. Factors contributing to this include:

- Diverse crop rotations
- Absence of synthetic pesticides and herbicides
- Habitat provision through hedgerows, buffer strips, and fallow lands

These practices create a favorable environment for a wide range of organisms and enhance overall biodiversity (Abbott & Manning, 2015).

2. Landscape-Level Impacts

Organic farming practices often incorporate features like hedgerows, field margins, and cover crops, which serve as habitats for various wildlife species (Hole, D. G., 2005). At a landscape scale, organic farms often act as biodiversity refuges, particularly in intensively farmed regions. They support pollinators, natural predators, and other beneficial organisms by maintaining ecological niches. These semi-natural habitats enhance landscape diversity and provide corridors for species movement, contributing to overall biodiversity. Studies have shown that such practices lead to higher densities of birds and other fauna in organic farms (Feber et al., 2015).

3. Genetic Diversity

Organic agriculture promotes the conservation and use of traditional crop varieties and breeds adapted to local conditions, contributing to agrobiodiversity. This approach ensures the preservation of genetic resources, essential for resilience and adaptation to environmental stresses (Liu et al., 2016).

4. Conservation of Indigenous Species

Organic farming can aid in the conservation of indigenous plant and animal species. For example, in West Bengal, India, initiatives have been undertaken to reintroduce near-extinct indigenous rice and fish varieties through organic cultivation methods. This approach not only preserves biodiversity but also supports cultural heritage and local food security (Liu et al., 2016).

5. Support for Beneficial Insects and Natural Pest Control

The avoidance of synthetic pesticides in organic farming creates a safer environment for beneficial insects, including pollinators and natural predators of pests. Research indicates that organic farms host a greater diversity and abundance of arthropods, such as spiders and predatory beetles, which contribute to natural pest control

mechanisms. For instance, spider densities have been found to be about 62% higher in organic farms compared to conventional ones (Reeve et al., 2016).

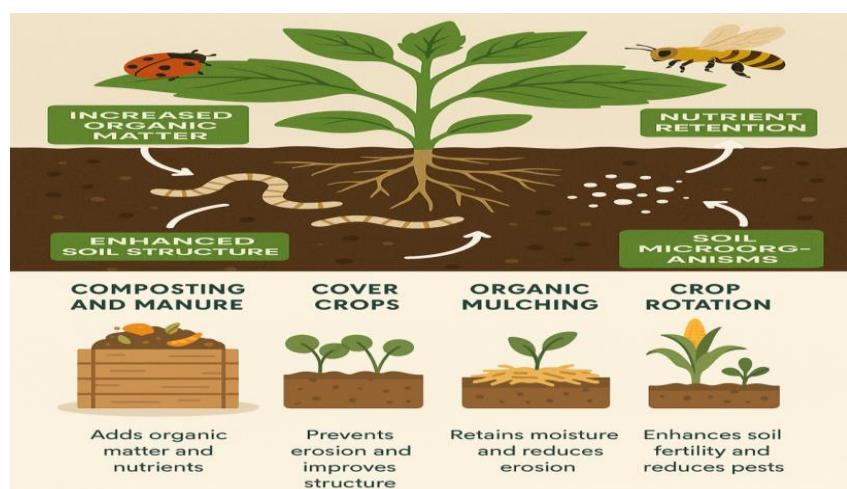
Table 2: Aspects of organic farming in biodiversity conservation.

Biodiversity Conservation	Aspects of Organic Farming
Species Richness	Supports a higher number and diversity of plant, insect, bird, and soil organism species compared to conventional farms.
Pollinator Protection	Eliminates harmful pesticides, providing a safe environment for bees, butterflies, and other pollinators.
Habitat Preservation	Maintains hedgerows, field margins, and natural vegetation that serve as habitats for wildlife.
Reduced Agrochemical Use	Avoids synthetic fertilizers and pesticides, reducing toxicity and pollution in ecosystems.
Soil Biodiversity	Enhances microbial and invertebrate diversity by maintaining organic matter and avoiding chemical disruption.
Landscape Diversity	Encourages diverse cropping systems and intercropping, which support a variety of organisms.
Ecosystem Services	Strengthens ecosystem functions like pollination, pest control, and nutrient cycling through biological diversity.
Genetic Diversity	Often relies on traditional and indigenous crop varieties, promoting genetic diversity in agriculture.

Organic Farming and Soil Health

Organic farming is a comprehensive agricultural method that prioritizes soil vitality as the cornerstone of long-term, sustainable food systems. By avoiding synthetic fertilizers and pesticides, organic farming nurtures the soil's natural fertility and biodiversity, leading to resilient ecosystems and nutritious crops. One of the primary benefits of organic farming is the enhancement of soil organic matter. Practices such as composting, green manuring, and the use of cover crops enrich the soil with organic materials, improving its structure, water retention, and nutrient availability. This not only supports plant growth but also fosters a diverse community of beneficial microorganisms that aid in nutrient cycling and disease suppression (Wen et al., 2025). Organic farming also promotes soil biodiversity. By eliminating synthetic chemicals, it creates a conducive environment for earthworms, fungi, and other soil organisms that play crucial roles in maintaining soil health. These organisms enhance soil structure, facilitate nutrient exchange, and improve plant resilience against pests and diseases (Coletta et al., 2025). Furthermore, organic practices contribute to soil conservation. Techniques like conservation tillage and cover cropping reduce soil erosion, maintain soil integrity, and prevent nutrient runoff. These methods not only preserve the topsoil but also enhance its capacity to sequester carbon, thereby mitigating climate change (Abrar et al., 2025). Real-world examples underscore the efficacy of organic farming. In Wardha, Maharashtra, farmer Shri Prabhakarrao Deotale transitioned to organic brinjal farming with guidance from Patanjali Ayurved, resulting in increased income and environmental sustainability. Similarly, in Ludhiana, Punjab, Sucha Singh Pabla adopted organic wheat cultivation, achieving a 50% profit margin by leveraging natural inputs and commanding premium prices for his chemical-free produce (Times of India, 2025). Organic farming offers a sustainable pathway to enhance soil health, ensuring long-term agricultural productivity and environmental conservation. By adopting organic practices, farmers contribute to a healthier planet and secure their livelihoods against the challenges of modern agriculture.

Figure 2: Impact of organic farming on soil health.



Soil health, defined by its capacity to function as a living ecosystem, is a cornerstone of organic agriculture.

1. Soil Organic Matter (SOM)

Organic farming enhances SOM through the use of compost, cover crops, and organic amendments. Increased SOM improves nutrient cycling, water retention and soil structure.

2. Soil Microbial Activity

The absence of harmful chemicals and the presence of organic inputs promote diverse and active microbial communities. These microbes contribute to nutrient availability, disease suppression, and soil resilience.

3. Soil Erosion and Compaction

Organic systems often employ cover crops and reduced tillage, minimizing erosion and maintaining soil porosity. This reduces runoff and increases infiltration rates.

Table 3: Effectiveness of organic practices on biodiversity and soil parameters.

Organic Farming Practice	Example	Microbial Involvement	Role in Biodiversity Conservation	Role in Soil Health
Use of Compost and Manure	Application of decomposed organic matter	Enhances microbial diversity (e.g., <i>Bacillus</i> , <i>Pseudomonas</i> , <i>Actinomycetes</i>)	Supports diverse microbial habitats, indirectly benefiting higher trophic levels	Improves organic matter, boosts microbial activity and nutrient cycling
Green Manuring	Incorporating legumes like clover or alfalfa	Promotes nitrogen-fixing bacteria (<i>Rhizobium</i> , <i>Azospirillum</i>)	Supports rhizosphere biodiversity and soil fauna	Enriches nitrogen content and microbial biomass
Vermicomposting	Using earthworms and microbes to decompose organic waste	Encourages growth of beneficial microbes (e.g., <i>Trichoderma</i> , <i>Streptomyces</i>)	Increases soil fauna and microbial interactions	Improves nutrient availability and soil enzyme activity
Biofertilizers	Inoculation with <i>Azotobacter</i> , <i>Rhizobium</i> , <i>Mycorrhiza</i>	Introduces beneficial microbes that fix nitrogen, solubilize phosphorus	Reduces dependence on synthetic inputs, enhancing soil biotic richness	Boosts soil fertility and root-microbe symbiosis
Reduced Tillage	Minimal soil disturbance	Protects native microbial communities and fungal networks like <i>Glomus</i> (AMF)	Preserves native microbial biodiversity and underground ecosystems	Prevents microbial habitat disruption and enhances carbon sequestration
Mulching with Organic Material	Use of straw, leaves, or bark	Encourages decomposers and fungal growth (<i>Penicillium</i> , <i>Aspergillus</i>)	Supports detritivore food webs and microbial diversity	Enhances soil moisture, temperature regulation, and microbial activity
Crop Rotation with Legumes	Rotating legumes with cereals or vegetables	Supports symbiotic nitrogen-fixing bacteria and pathogen-suppressing microbes	Encourages diverse microbial niches and beneficial fungi	Maintains nutrient balance and suppresses soil-borne diseases
Mycorrhizal Inoculation	Adding arbuscular mycorrhizal fungi (AMF) to crops	<i>Glomus</i> , <i>Gigaspora</i> , and others form mutualistic root associations	Enhances belowground biodiversity and supports plant-microbe interactions	Improves nutrient and water uptake, soil structure
Biocontrol Agents	Using <i>Trichoderma</i> or <i>Bacillus subtilis</i> against pathogens	Controls soil pathogens through microbial antagonism	Reduces chemical use, preserving native microbial communities	Protects plant roots and maintains soil microbial balance
Use of Fermented Plant Extracts	Liquid manures like Panchagavya or Bokashi	Rich in lactic acid bacteria, yeast, and other fermentative microbes	Increases microbial diversity and functional redundancy	Improves nutrient availability and disease suppression

Comparative Studies and Empirical Evidence

Numerous studies support the positive impact of organic farming on biodiversity and soil health:

- A meta-analysis by Bengtsson et al. (2005) found 30% higher species richness on organic farms.

- Soil quality indicators such as microbial biomass and enzymatic activity are consistently higher in organically managed soils (Mäder et al., 2002).
- Organic systems show greater resilience to climate change and extreme weather through improved soil structure and water-holding capacity.

Challenges and Limitations

Organic farming, while offering substantial benefits for biodiversity conservation and soil health, faces several challenges and limitations that impact its scalability and effectiveness. One key challenge is the lower and sometimes inconsistent crop yields compared to conventional farming, especially during the transition period, which can deter widespread adoption. Additionally, the effectiveness of organic practices is highly context-dependent, influenced by local soil conditions, climate, and crop types, making it difficult to standardize best practices. The limited availability and variable quality of organic inputs such as compost, biofertilizers, and microbial inoculants also hinder consistent results. Moreover, knowledge gaps regarding soil microbial dynamics and their interactions with organic amendments restrict the full utilization of microbe-based approaches to soil health. Farmers often lack access to technical support and training on organic methods, and certification processes can be complex and costly. These challenges underscore the need for targeted research, policy support, and capacity building to overcome current limitations and fully realize the ecological potential of organic farming systems.

Policy Implications and Future Directions

Policy support is crucial to advancing organic farming as a sustainable strategy for biodiversity conservation and soil health enhancement. Future agricultural policies should prioritize research and development focused on soil microbiome functions, standardize quality regulations for organic inputs, and incentivize practices that foster microbial diversity and ecological balance. Subsidies and transition support programs can help mitigate the initial yield gap and encourage farmers to adopt organic systems. Integrating organic farming into national biodiversity and climate action plans, coupled with farmer education and improved extension services, can bridge knowledge gaps and promote evidence-based practices. Additionally, creating robust monitoring frameworks to evaluate the ecological impact of organic methods will help shape adaptive, region-specific policies. By aligning agricultural sustainability goals with microbial and biodiversity conservation, future policy directions can ensure more resilient, productive, and environmentally sound farming systems.

Conclusion

Organic farming presents a viable pathway to sustainable agriculture by enhancing biodiversity and restoring soil health. Its holistic approach contributes to the resilience and sustainability of food systems. While not a panacea, organic farming is a critical component of a broader transition towards ecologically sound agricultural practices. By avoiding synthetic inputs and embracing practices such as crop rotation, composting, and the use of organic fertilizers, organic agriculture fosters a diverse ecosystem both above and below the soil surface. Studies indicate that organic farms support higher species richness among flora and fauna, including beneficial insects and soil microorganisms, which are essential for ecosystem services like pollination and natural pest control. Moreover, organic farming practices improve soil structure, increase organic matter content, and enhance microbial activity, leading to better nutrient cycling and water retention. These improvements not only bolster crop resilience against environmental stresses but also contribute to long-term soil fertility and productivity. However, the transition to organic farming is not without challenges. Farmers may face initial yield reductions, labor-intensive management requirements, and market access limitations. Additionally, the need for comprehensive knowledge and training in organic practices can be a barrier to adoption. Addressing these challenges requires supportive policies, research investments, and education programs to facilitate the adoption of organic methods. Despite certain limitations, organic farming plays a significant role in promoting biodiversity and enhancing soil health. With appropriate support and ongoing research, it can contribute substantially to the development of sustainable food systems and the achievement of environmental conservation objectives.

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Conflicts of interest

The authors declare that there are no conflicts of interest regarding the publication of this paper.

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